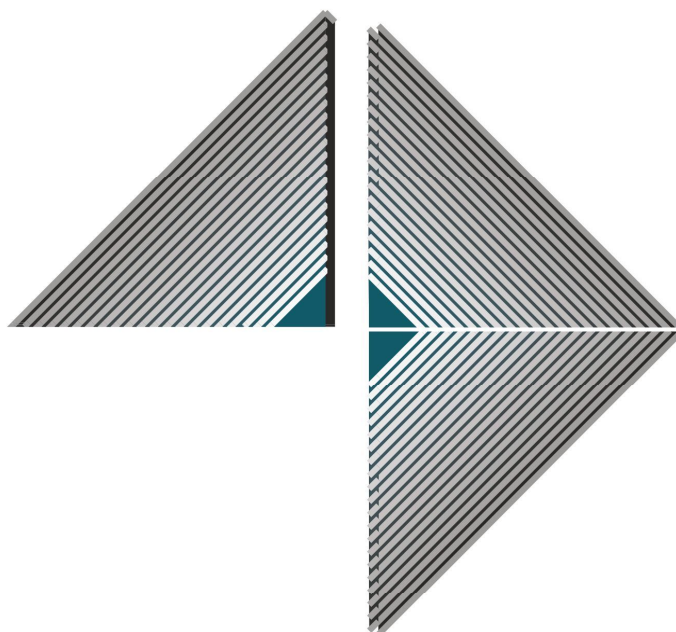


Vol. 84, No. 3, 2026



PROBLEMS
OF EDUCATION
IN THE 21st
CENTURY



PROBLEMS OF EDUCATION IN THE 21st CENTURY

ISSN 1822-7864



PROBLEMS OF EDUCATION IN THE 21st CENTURY

Scientia Socialis, Ltd., a member of the *Lithuanian Publishers Association and a member of Publishers International Linking Association, Inc. (Crossref)* in cooperation with SMC „Scientia Educologica“, Lithuania, *The Associated Member of Lithuanian Scientific Society, European Society for the History of Science (ESHS) and ICASE (International Council of Associations for Science Education)*

The articles appearing in this journal are indexed, listed, and abstracted in:

Emerging Sources Citation Index (ESCI) (Web of Science Clarivate Analytics)	Directory of Open Access Scholarly Resources (ROAD)
ERIC	Eurasian Scientific Journal Index
Index Copernicus	Crossref
EBSCO: Education Research Complete	ProQuest (ProQuest Central; ProQuest Education Journals)
Education Research Index Database Coverage List “Core” coverage	Europub: Academic and Scholarly Research Publication Center
Central & Eastern European Academic Source Database Coverage List (EBSCO-CEEAS)	The Scientific Literature Database (Scilit)
JournalSeek	QOAM
Ulrich’s Periodicals Directory	DOI
Contemporary Science Association/AAP databases	ResearchGate
Open Academic Journals Index (OAJI)	Dimensions
Zeitschriften Datenbank (ZDB)	SOBIAD
GIGA Information Centre (Electronic Journals Library)	CEEOL (Central and Eastern European Online Library)
CNKI (China National Knowledge Infrastructure) Scholar	Scribd
Turkish Education Index	Researcher.Life
Information Matrix for the Analysis of Journals (MIAR)	Exaly
	Asian Science Citation Index

Publisher

Scientia Socialis, Ltd. in cooperation with SMC „Scientia Educologica“, Lithuania, the Associated Member of Lithuanian Scientific Society, the Association of Lithuanian Serials, European Society for the History of Science (ESHS) and International Council of Associations for Science Education (ICASE)

Editors-in-Chief

Dr., Prof. **Aginaldo Arroio**, University of Sao Paulo, Brazil

Dr., Prof. **Vincentas Lamanauskas**, Vilnius University & SMC „Scientia Educologica“, Republic of Lithuania

Editorial Board

Dr., Prof. **Boris Aberšek**, University of Maribor, Slovenia

Dr., Prof. **Saleh A. Alabdulkareem**, King Saud University, Saudi Arabia

Dr. **Monica Baptista**, University of Lisbon, Portugal

Dr., Prof. **Martin Bilek**, Charles University, Czech Republic

Dr., Prof. **Andris Broks**, University of Latvia, Latvia

Dr., Prof. **Marco Antonio Bueno Filho**, Federal University of ABC, Brazil

Dr. **Paolo Bussotti**, University of Udine, Italy

Dr., Prof. **Muammer Calik**, Trabzon University, Turkey

Dr. **Saša A. Horvat**, University of Novi Sad, Republic of Serbia

Dr., Prof. **Margaret Chan Kit Yok**, MARA University of Technology (UiTM), Malaysia

Dr., **Angela James**, University of Kwazulu – Natal, South Africa

Dr., Prof. **Vladimir S. Karapetyan**, Armenian State Pedagogical University named after Kh. Abovyan, Armenia

Dr., Prof. **Kuo-Hung Huang**, National Chiayi University, Taiwan

Dr. **Milan Kubiato**, Silesian University, Czech Republic

Dr., Prof. **Mirosław Kowalski**, University of Zielona Góra, Poland

Dr., Prof. **Lay Yoon Fah**, University Malaysia Sabah, Malaysia

Dr. **Todar T. Lakhvich**, Belarusian State Medical University, Republic of Belarus

Dr. **Solange W. Locatelli**, Federal University of ABC, Brazil

Dr., Prof. **Danuše Nezvalová**, Palacký University, Czech Republic

Dr. **Osman Pekel**, Suleyman Demirel University, Turkey

Dr., Prof. **Yuriy Pelekh**, Rivne State University of Humanities, Ukraine

Dr., Prof. **Raffaele Pisano**, University of Lille, France

Dr., Prof. **Katarzyna Potyrala**, Cracow University of Technology, Poland

Dr. **Costin Pribeanu**, Academy of Romanian Scientists, Romania

Dr. **Agneta Simeonsdotter Svensson**, University of Gothenburg, Sweden

Dr. **Uladimir K. Slabin**, University of Oregon, USA

Dr. **Laima Railienė**, Scientific Methodical Centre „Scientia Educologica“, Republic of Lithuania

Dr., Prof. **Borislav V. Toshev**, Sofia University, Bulgaria

Dr., Prof. **Milan Turčani**, Constantine the Philosopher University, Slovakia

Dr. Prof. **Muhammet Usak**, University of Kragujevac, Republic of Serbia

Dr., Prof. **Nicos Valanides**, Educational Robotics and Science Organization, Cyprus

Copyright of this issue is the property of Scientia Socialis, Ltd, Lithuania. By virtue of their appearance in this open access journal, articles are free to use, with proper attribution, in educational and other non-commercial settings

Index Copernicus (ICTM Value): 100.00 (2024); ICDS (Secondary Composite Index Broadcasting): 9.5 (2018). CGIJ OAJI: 0.600 (2022). H Index: 11 (2024), Journal Citation Indicator (JCI) / Clarivate: 0.38 (2021)

Problems of Education in the 21st Century is an international, periodical, peer reviewed scientific journal, issued by the Scientia Socialis Ltd. in cooperation with SMC „Scientia Educologica“.

Address: Scientia Socialis, Ltd.

Donelaičio Street 29, LT-78115 Siauliai, Lithuania

E-mail: scientia@scientiasocialis.lt

Phone: +370 687 95668

WEB page: <http://www.scientiasocialis.lt/pec>

Contents

Editorial

ARTIFICIAL INTELLIGENCE IN CHEMISTRY EDUCATION: OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS Saša A. Horvat, Valentina Periškić.....	378
--	-----

Articles

TEACHERS' STRATEGIES FOR BUILDING CLASSROOM COMMUNITY IN SLOVAK PRIMARY EDUCATION Ružena Čiliaková, Simoneta Babiaková.....	382
CROSS-CULTURAL COMPETENCE AND SKILLS IN HIGHER EDUCATION: A GENERALIZED LINEAR MODELING APPROACH TOWARDS A CULTURE-BASED EXTENSION PROGRAM Mary Grace O. Gallego	398
EARTHQUAKE LITERACY AND AWARENESS AMONG LOWER-SECONDARY SCHOOL STUDENTS Eytem Yalçinkaya-Önder, Selin Tatli.....	417
AGRICULTURAL AWARENESS EDUCATION FOR STUDENTS WITH MILD INTELLECTUAL DISABILITIES: AN ACTIVITY-BASED APPROACH Taner Küçük, İsmail Satmaz	445
RESEARCHER IN THE MAKING: DISCIPLINE-SPECIFIC RESEARCH READINESS AND CAREER INTENTIONS Marianna Lőrincz, Hanna Tovkanets, Oksana Tovkanets, Ildikó Greba.....	465
EFFECTS OF A SHORT-TERM TEACHER PROFESSIONAL DEVELOPMENT ON PHYSICS LEARNING UNDER SEVERE RESOURCE CONSTRAINTS: CONCEPTUAL AND SYMBOLIC GAINS WITHOUT PROCEDURAL IMPROVEMENT Tade-Etienne N. Mbundu, Ruffin-Benoît M. Ngoie, Jean-Roger M. Bansimba, God'El K. Kinyoka, Rama M. Bazangika, Billy Nzau Matondo	480
MAKING PERFORMANCE TEACHABLE: CURRICULAR ALIGNMENT AND MICROTEACHING IN GROUP PIANO TEACHER EDUCATION Min Xu, Pan Li, Baiyun Zhou, Xuan Yi.....	505
DIGITAL TECHNOLOGIES IN VOCATIONAL EDUCATION: FROM TECHNOLOGY ADOPTION TO SOCIO-TECHNICAL TRANSFORMATION Bo Zhou, Seong Pek Lim, Nahdia Kabir, Jin Tao, Jiaying Yang, Cong Wang	525

Information

INSTRUCTIONS FOR AUTHORS	542
--------------------------------	-----



ARTIFICIAL INTELLIGENCE IN CHEMISTRY EDUCATION: OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS

Saša A. Horvat, Valentina Periškić

University of Novi Sad, Republic of Serbia

E-mail: sasa.horvat@dh.uns.ac.rs, perickicvalentina@gmail.com

The rapid development of artificial intelligence (AI) has become one of the most significant technological transformations of the 21st century. In recent years, AI-powered tools have increasingly entered educational environments, influencing how knowledge is accessed, processed, and communicated. Generative AI systems, particularly large language models such as ChatGPT, have attracted considerable attention due to their ability to generate human-like responses, support problem-solving, create educational materials, and facilitate communication between learners and educators (Araujo & Saude, 2024; Clark et al., 2023). As these technologies become more accessible, educational institutions face an important challenge: how can AI be integrated into teaching and learning in ways that enhance educational quality while preserving the fundamental goals of education?

The discussion surrounding AI in education extends beyond technological innovation. AI is increasingly viewed as a tool capable of supporting personalized learning, improving accessibility, and fostering student engagement (Araujo & Saude, 2024). Unlike traditional digital resources, generative AI systems can interact with users, adapt explanations to individual needs, and provide immediate feedback. Consequently, they have the potential to transform educational practices across different disciplines and educational levels.

Chemistry education represents a particularly relevant context for examining the educational potential of AI. Learning chemistry is inherently challenging because students are required to connect observable phenomena with invisible particulate processes and symbolic representations. According to Johnstone's triplet model, meaningful understanding of chemistry depends on successful integration of macroscopic, submicroscopic, and symbolic levels of representation (Johnstone, 1991; Talanquer, 2011). Students frequently experience difficulties in establishing these connections, which often results in fragmented understanding and persistent misconceptions. Therefore, educational innovations capable of supporting conceptual understanding are of particular interest in chemistry education.

One of the most frequently discussed advantages of AI is its capacity to support personalized learning. Students differ considerably in their prior knowledge, learning pace, motivation, and preferred learning strategies. Traditional classroom instruction often struggles to address these differences effectively. AI-powered systems can provide individualized explanations, generate additional practice tasks, offer adaptive feedback, and modify the complexity of learning materials according to student needs (Araujo & Saude, 2024; Yik & Dood, 2024). Such support may be particularly valuable in chemistry, where abstract concepts and complex problem-solving procedures often require repeated explanations and alternative instructional approaches.

The application of AI also offers new possibilities for developing students' problem-solving skills. Modern AI systems can guide learners through complex calculations, explain individual solution steps, and provide alternative approaches to solving chemical problems

(Araujo & Saude, 2024; Clark et al., 2023). When used appropriately, these tools can help students focus on conceptual understanding rather than solely on procedural execution. Furthermore, AI-generated explanations and examples may contribute to reducing cognitive barriers that frequently accompany the learning of chemistry.

Laboratory instruction constitutes another area in which AI may provide substantial educational benefits. Practical work remains one of the most important components of chemistry education because it enables students to connect theoretical knowledge with experimental evidence. However, laboratory activities are frequently constrained by limited resources, equipment availability, safety considerations, and time restrictions. AI tools can assist educators in designing laboratory activities, adapting experimental procedures to available resources, and creating context-based learning scenarios that enhance student engagement (Araujo & Saude, 2024; Trčková et al., 2024). In addition, AI may support students in preparing laboratory reports, interpreting experimental results, and reflecting on their findings.

Beyond supporting student learning, AI offers numerous opportunities for educators and researchers. Teachers may use AI to assist in lesson planning, assessment design, rubric development, and preparation of instructional materials (Clark et al., 2024; Fernández et al., 2024). Researchers can employ AI-powered tools for literature exploration, data analysis, and organization of scientific information (Wang et al., 2023; Zheng et al., 2023). Such applications may reduce administrative workload and allow educators to devote greater attention to pedagogical decision-making, mentoring, and direct interaction with students.

Despite these opportunities, the educational use of AI should not be approached uncritically. One of the most significant concerns involves the reliability and scientific accuracy of AI-generated content. Generative AI models occasionally produce inaccurate explanations, fabricated references, or scientifically incorrect information while presenting these outputs in a highly convincing manner (Exintaris et al., 2023; Ruff et al., 2024). In chemistry education, where precision and scientific rigor are essential, even minor inaccuracies may contribute to the development of misconceptions and misunderstanding. Consequently, both teachers and students must develop the ability to critically evaluate AI-generated information rather than accepting it uncritically.

Another challenge relates to the risk of passive learning. The educational value of AI depends largely on how it is used. If students rely on AI primarily as a source of ready-made answers, opportunities for independent reasoning, problem-solving, and knowledge construction may be diminished (Exintaris et al., 2023; Guo & Lee, 2023). Excessive dependence on AI could potentially reduce students' motivation to engage deeply with scientific concepts and weaken the development of critical thinking skills. Therefore, educational practices should encourage learners to evaluate, critique, and improve AI-generated responses rather than merely consuming them.

Particularly valuable educational opportunities may emerge when AI is used as an object of critical analysis. Students can be asked to identify errors, evaluate the validity of explanations, compare AI-generated responses with scientific sources, and justify their conclusions. Such activities transform AI from a simple information provider into a catalyst for critical thinking and metacognitive development (Clark et al., 2024; Exintaris et al., 2023; Guo & Lee, 2023). In this context, AI becomes a tool for learning about knowledge construction rather than merely acquiring information.

Additional concerns involve issues of accessibility, ethics, and safety. Advanced AI systems often require paid subscriptions, potentially creating inequalities among learners and educational institutions (Emenike & Emenike, 2023; Jaroonchokanan & Sirisathitkul, 2025). Furthermore, AI-generated laboratory suggestions may occasionally overlook important safety considerations or propose procedures that require careful professional verification (Araujo & Saude, 2024; Ruff et al., 2024). These limitations emphasize the continuing necessity of human supervision and professional responsibility in educational settings.

Perhaps the most important educational question raised by AI is not whether students will use AI, but how its presence will reshape the goals of chemistry education. For decades, chemistry instruction has focused heavily on the acquisition and reproduction of knowledge, requiring students to recall concepts, solve calculations, and apply established procedures. However, generative AI systems are now capable of providing explanations, solving quantitative problems, generating laboratory protocols, and even producing scientifically sounding reports within seconds. AI will not transform chemistry education simply because it can provide answers. Rather, it will transform chemistry education because it forces educators to redefine what it means to understand chemistry. If students can instantly obtain explanations, calculations, and laboratory protocols from AI systems, chemistry education can no longer focus primarily on information transmission. Consequently, future chemistry education may place greater emphasis on scientific reasoning, critical evaluation of information, interpretation of evidence, the ability to distinguish scientifically valid explanations from plausible but incorrect ones, and the responsible use of digital technologies (Emenike & Emenike, 2023; Exintaris et al., 2023; Guo & Lee, 2023; Ruff et al., 2024). In this context, the educational value of AI does not lie in replacing human thinking but in creating new opportunities for its development. Students should be encouraged to question AI-generated responses, identify inaccuracies, compare alternative explanations, and justify their conclusions using scientific evidence. Such practices can transform AI from a provider of answers into a catalyst for deeper learning, critical thinking, and metacognitive development.

The future of chemistry education may therefore depend less on the capabilities of AI itself and more on educators' ability to design learning environments in which technology supports, rather than substitutes, meaningful scientific inquiry in ways that promote understanding, curiosity, scientific literacy, and lifelong learning. From this perspective, the role of teachers becomes even more important rather than less significant. AI cannot replace the pedagogical expertise, ethical judgment, and professional experience required to support meaningful learning. Instead, it should be viewed as a complementary tool that enhances educational practice while leaving essential educational decisions in human hands. Teachers remain responsible for ensuring scientific accuracy, promoting critical thinking, fostering student motivation, and creating safe learning environments.

The central question is therefore no longer whether AI will become part of chemistry education. Its presence in educational practice is already a reality. Its greatest potential lies in supporting human expertise and enriching educational experiences. When combined with sound pedagogical principles and critical evaluation, AI may become a valuable partner in advancing chemistry education and preparing students for the increasingly complex scientific and technological challenges of the future. In this new educational landscape, the teacher remains indispensable—not as a source of answers, but as a guide who helps students transform information into understanding and understanding into knowledge.

References

- Araujo, J. L. & Saude, I. (2024). Can ChatGPT enhance chemistry laboratory teaching? Using prompt engineering to enable AI in generating laboratory activities. *Journal of Chemical Education*, 101(5), 1858–1864. <https://doi.org/10.1021/acs.jchemed.3c00745>
- Clark, T. M., Anderson, E., Dickson-Karn, N. M., Soltanirad, C., & Tafini, N. (2023). Comparing the performance of college chemistry students with ChatGPT for calculations involving acids and bases. *Journal of Chemical Education*, 100(10), 3934–3944. <https://doi.org/10.1021/acs.jchemed.3c00500>
- Clark, T. M., Fhaner, M., Stoltzfus, M., & Queen, M. S. (2024). Using ChatGPT to support lesson planning for the historical experiments of Thomson, Millikan and Rutherford. *Journal of Chemical Education*, 101(5), 1992–1999. <https://doi.org/10.1021/acs.jchemed.4c00200>
- Clark, J. M., Reynders, M. & Holme, T. A. (2024). Students' Experience of a ChatGPT Enabled Final Exam in a Non-Majors Chemistry Course. *Journal of Chemical Education*, 101(5), 1983–1991. <https://doi.org/10.1021/acs.jchemed.4c00161>

- Emenike, M. E., & Emenike, B. U. (2023). Was this title generated by ChatGPT? Considerations for artificial intelligence text- generation software programs for chemists and chemistry educators. *Journal of Chemical Education*, 100(4), 1413–1418. <https://doi.org/10.1021/acs.jchemed.3c00063>
- Exintaris, B., Karunaratne, N., & Yuriev, E. (2023). Metacognition and critical thinking: Using ChatGPT-generated responses as prompts for critique in a problem- solving workshop (SMARTCHEMPER). *Journal of Chemical Education*, 100(8), 2972–2980. <https://doi.org/10.1021/acs.jchemed.3c00481>
- Fernandez, A. A., Lopez-Torres, M., Fernandez, J. J., & Vazquez-Garcia, D. (2024). ChatGPT as an instructor's assistant for generating and scoring exams. *Journal of Chemical Education*, 101(9), 3780–3788. <https://doi.org/10.1021/acs.jchemed.4c00231>
- Guo, Y., & Lee, D. (2023). Leveraging ChatGPT for enhancing critical thinking skills. *Journal of Chemical Education*, 100(12), 4876–4883. <https://doi.org/10.1021/acs.jchemed.3c00505>
- Jaroonchokanan, N., & Sirisathitkul, C. (2025). Implementing ChatGPT as tutor, tutee and tool in physics and chemistry. *Substantia*, 9(1), 89–101. <https://doi.org/10.36253/Substantia-2808>
- Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of computer assisted learning*, 7(2), 75–83. <https://doi.org/10.1111/j.1365-2729.1991.tb00230.x>
- Ruff, E. F., Engen, M. A., Franz, J. L., Mauser, J. F., West, J. K., & Zemke, J. M. O. (2024). ChatGPT writing assistance and evaluation assignments across the chemistry curriculum. *Journal of Chemical Education*, 101(6), 2483–2492. <https://doi.org/10.1021/acs.jchemed.4c00248>
- Talanquer, V. (2011). Macro, submicro, and symbolic: The many faces of the chemistry “triplet”. *International Journal of Science Education*, 33(2), 179–195. <https://doi.org/10.1080/09500690903386435>
- Trčkova, K., Maršalek, R., Žaček, M., & Tepla, M. (2024). Why do fishes die? Lab assignment created using ChatGPT. *Journal of Chemical Education*, 101(8), 3171–3178. <https://doi.org/10.1021/acs.jchemed.4c00130>
- Yik, B. J., & Dood, A. J. (2024). ChatGPT convincingly explains organic chemistry reaction mechanisms slightly inaccurately with high levels of explanation sophistication. *Journal of Chemical Education*, 101(5), 1836–1846. <https://doi.org/10.1021/acs.jchemed.4c00235>
- Wang, R., Feng, H., & Wei, G. (2023). ChatGPT in drug discovery: A case study on anticocaine addiction drug development with Chatbots. *Journal of Chemical Information and Modeling*, 63(22), 7189–7209. <https://doi.org/10.1021/acs.jcim.3c01429>
- Zheng, Z., Zhang, O., Borgs, C., Chayes, J. T., & Yaghi, O. M. (2023). ChatGPT chemistry assistant for text mining and the prediction of MOF synthesis. *Journal of the American Chemical Society*, 145(32), 18048–18062. <https://doi.org/10.1021/jacs.3c05819>

Received: May 24, 2026

Revised: May 30, 2026

Accepted: June 12, 2026

Cite as: Horvat, S. A., & Periškić, V. (2026). Artificial intelligence in chemistry education: Opportunities, challenges, and future directions. *Problems of Education in the 21st Century*, 84(3), 378–381. <https://doi.org/10.33225/pec/26.84.378>

Saša A. Horvat
(Corresponding author)

PhD, Associate Professor, Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Novi Sad, Republic of Serbia.
E-mail: sasa.horvat@dh.uns.ac.rs
Website: <https://www.dh.uns.ac.rs/dr-sasa-horvat-vanredni-profesor/>
ORCID: <https://orcid.org/0000-0002-4744-0375>

Valentina Periškić

Master Student, Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Novi Sad, Republic of Serbia.
E-mail: perickicvalentina@gmail.com



TEACHERS' STRATEGIES FOR BUILDING CLASSROOM COMMUNITY IN SLOVAK PRIMARY EDUCATION

Ružena Čiliaková, Simoneta Babiaková

Matej Bel University in Banská Bystrica, Slovakia

E-mail: ruzena.ciliakova@umb.sk, simoneta.babiakova@umb.sk

Abstract

Building a classroom community is an important dimension of primary teachers' professional practice. It influences classroom climate, children's engagement, and their social development. However, less is known about the specific pedagogical strategies through which classroom community is built in everyday classroom practice. The aim of the study was to identify and interpret pedagogical strategies used by primary school teachers to build classroom community. The study was designed as a qualitative follow-up to a previous quantitative survey. The empirical material consisted of 137 written reflections produced by future teachers who observed teaching as part of their teaching internship in 137 primary school classrooms. Data were analyzed using qualitative content analysis combining deductive and inductive procedures across four analytical areas: acceptance and inclusion, classroom behavioral regulation, teamwork and communication, and children's self-assessment and responsibility for learning. The analysis revealed a wide range of pedagogical strategies used by teachers in everyday classroom practice. These strategies reflected two broader regulatory orientations of teaching practice: participatory-preventive approaches that support cooperation, reflection and children's autonomy, and directive-reactive approaches based primarily on external regulation and behavioral control. The findings suggest that classroom community-building is shaped not by isolated techniques, but by broader pedagogical strategies that reflect different regulatory orientations in classroom practice. These strategies regulate participation, relationships, behavior, and learning in everyday classroom practice.

Keywords: *classroom community, classroom regulation, primary education, qualitative content analysis, teacher strategies*

Introduction

Contemporary educational research has increasingly emphasized that effective learning environments depend not only on teaching methods but also on the quality of social relationships and classroom interactions. Classroom community represents an important relational dimension of schooling. It integrates cooperation, mutual respect and shared responsibility among children (Darling-Hammond et al., 2020; OECD, 2021). Research on classroom climate has shown that children's engagement, motivation and emotional well-being are strongly influenced by everyday pedagogical practices. These practices have shaped how teachers organize interaction and regulate behavior in the classroom (Aldrup et al., 2020; Wang & Degol, 2020). Teachers therefore play a key role not only as facilitators of learning but also as architects of the classroom social environment. Can et al. (2025) and Vančíková et al. (2025) have also emphasized the importance of valuing every child, together with the ethical role of teachers, empathy, and justice in creating a positive educational environment.

From this perspective, building classroom community can be understood as a complex pedagogical process. It involves both relational and regulatory dimensions of teaching practice. Teachers create supportive relationships, organize opportunities for collaboration, and regulate

behavior through formal and informal norms. Immordino-Yang et al. (2019) and Panadero et al. (2023) have argued that these processes are closely linked to the development of children's social, emotional, and self-regulatory competences. In this sense, classroom community-building involves both relational support and the regulation of participation, cooperation, and behavior. Cumhur (2022) has suggested that effective teacher guidance should support understanding, strategic action, and evaluative thinking in learning processes.

A broader conceptual framework for understanding the development of children's life skills in schools is Social and Emotional Learning (SEL). SEL includes five key competences: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making (Durlak et al., 2011). A meta-analysis of 213 school-based universal SEL programs has shown that participants demonstrated significantly better social and emotional skills, attitudes, behavior, and academic performance than children in control groups (Durlak et al., 2011). Subsequent findings have further strengthened the empirical basis of SEL by showing that its benefits were broadly similar regardless of race, socioeconomic background, or school setting (Taylor et al., 2017). At the same time, evidence from whole-school interventions has suggested a more differentiated picture. Goldberg et al. (2019) have reported significant but rather small improvements in social and emotional adjustment, behavioral adjustment, and internalizing symptoms, while no significant effects on academic outcomes have been confirmed. These findings suggest that the development of social and emotional competences is educationally important, but that its effects depend not only on formal programs, but also on how these principles are translated into everyday school and classroom practice.

This perspective is directly relevant to classroom community-building. If social and emotional development is not reduced to isolated interventions, then classroom community becomes one of the key contexts in which these competences are enacted, supported, and regulated in everyday school life. Building classroom community therefore cannot be understood only as creating a positive atmosphere. It also includes the ways in which teachers respond to difference, organize cooperation, support reflection, and regulate behavior in relation to participation and learning.

Current international literature has supported this interpretation. Research has emphasized the importance of emotionally supportive classroom environments, teacher-student relationships, inclusive practices, cooperative learning, and formative feedback for children's engagement and well-being (Immordino-Yang et al., 2019; Gillies, 2016; Panadero, 2023). Recent discussion has also focused on how SEL should be integrated into teacher education. In this context, scholars have emphasized the need to prepare teachers to implement SEL in line with global good practice and have pointed to its transformative potential for creating inclusive educational environments (Parween & Raza, 2025). At the same time, much of the international research has remained program-oriented. It has focused mainly on the implementation of SEL programs, whole-school approaches, mental health promotion, prevention of risk behavior, and well-being support (Domitrovich et al., 2017; Greenberg & Kusché, 2006). Considerably less attention has been paid to the concrete pedagogical strategies through which classroom community is built in everyday classroom practice, especially in primary education.

This gap is even more visible in Central European research. Compared with the broader international literature, research on children's life skills and social-emotional development in this region has been characterized by terminological inconsistency, conceptual fragmentation, and a lower number of empirical studies and meta-analyses. Systematic evaluations of school-based programs have remained limited. In Slovakia, this field is still relatively unsystematic, conceptually dispersed, and only partly grounded in empirical evidence. At the same time, current discussions on curriculum reform indicate that these issues are highly relevant. Porubský (2024) has argued that primary education should move beyond a traditional transmission model of teaching and should more strongly support cooperation, social responsibility, and children's

active participation in learning. In a related line of study, Rochovská (2026) has shown that pedagogical orientations in the Slovak context differ in the degree to which they emphasize authority, flexibility, and respect for the child's individuality, while also pointing to the value of strengthening more personalized and flexible elements within formal education. From this perspective, classroom community becomes an important framework for the development of these competences in Slovak primary education.

Research Problem

Previous Slovak research has already shown that the type of school may influence teachers' professional activities aimed at developing children's life skills, whereas the length of teaching experience appears to be less significant (Čiliaková & Babiaková, 2025). However, those findings were based on quantitative indicators and could not adequately capture how such activities are enacted in classroom situations, how they are combined in practice, or what broader pedagogical logic underlies them.

This is the central problem addressed in the present study. Although previous scholarship has demonstrated the importance of classroom climate, teacher–student relationships, and life skills in primary education, less is known about the concrete pedagogical strategies through which teachers build classroom community in everyday classroom practice. This lack of knowledge is relevant not only nationally, but also internationally. It concerns a question that is often overshadowed by program evaluation: how teachers actually translate relational, inclusive, and regulatory principles into situated classroom action.

A deeper understanding of this issue is particularly important in primary education, where classroom community plays a central role in children's social participation, engagement in learning, and sense of belonging. Building classroom community is not limited to supportive relationships alone. It also includes the ways in which teachers organize cooperation, respond to differences among children, regulate behavior, and create opportunities for reflection and responsibility. These processes require qualitative inquiry capable of identifying specific pedagogical strategies and interpreting their broader regulatory meaning.

Research Focus

The present study shifts attention from general indicators of classroom climate to specific pedagogical strategies visible in classroom practice. It focuses on four analytical areas that are theoretically and practically relevant to classroom community-building: acceptance and inclusion, classroom behavioral regulation, teamwork and communication, and self-assessment and responsibility for learning.

Within these areas, the study moves beyond identifying whether professional activities occur. Instead, it examines how they are pedagogically enacted and what broader regulatory orientations they reflect. In this sense, the study is concerned not only with what teachers do, but also with the pedagogical logic through which participation, relationships, behavior, and learning are organized in everyday classroom life.

This focus also provides the rationale for the methodological design. The study draws on structured reflections produced by future teachers during their teaching internship in primary school classrooms. These reflections offer systematically collected descriptions of classroom situations that make it possible to reconstruct recurring pedagogical strategies across a relatively broad set of school contexts. This makes them suitable for a qualitative follow-up study aimed at deepening previous quantitative findings through interpretive analysis of classroom practice.

Research Aim and Research Questions

The aim of this study was to identify and interpret the range of pedagogical strategies used by primary school teachers to build classroom community. The study also sought to conceptualize these strategies within a framework of regulatory orientations and to examine how participatory-preventive and directive-reactive approaches were manifested in everyday educational practice.

To achieve this aim, the study addressed the following research questions:

RQ1: What specific pedagogical strategies do primary school teachers utilize to facilitate the formation of classroom community?

RQ2: How are these strategies manifested across the four predefined analytical dimensions: acceptance and inclusion, behavioral regulation, teamwork and communication, and children's responsibility for learning?

RQ3: What broader regulatory orientations characterize the identified pedagogical strategies in the observed classroom contexts?

Research Methodology

Background

This study was designed as a qualitative follow-up to previous quantitative research by Čiliaková and Babiaková (2025). Its purpose was to deepen understanding of how classroom community-building is enacted in practice by analysing student-mediated reflections of observed classroom situations. The data collection process was completed in 2024. The qualitative analysis of the data was carried out in 2025–2026.

Sample

The empirical material consisted of 137 written reflections produced by future teachers enrolled in a primary teacher education program. The observations were conducted in 137 primary school classrooms across Slovak regions. The original sample was purposively constructed to include respondents relevant to the broader research focus on children's life skills development in primary education. In terms of school type, 115 classrooms (84%) were located in state schools and 22 classrooms (16%) in non-state schools. In the preceding quantitative phase of the research, the observed classroom teachers were also differentiated according to length of teaching experience: 21 teachers had 0–7 years of experience, 31 had 8–15 years, 39 had 16–23 years, 19 had 24–30 years, and 27 had 31 years or more (Čiliaková & Babiaková, 2025).

For the purposes of the present follow-up study, the unit of analysis was not the teacher or the classroom as such, but the written reflections produced by the observer. The study therefore analyses mediated descriptions and interpretations of teachers' classroom practices rather than direct recordings of classroom interaction.

Instrument and Procedures

The study employed a qualitative design as a follow-up to a previous quantitative survey (Čiliaková & Babiaková, 2025). It used qualitative content analysis combining deductive and inductive procedures to interpret pedagogical actions as reflected in authentic classroom settings. Data collection took place during a continuous 13-week internship, which allowed for a longitudinal perspective on recurring pedagogical patterns. The observers used a structured

observation sheet (see Table 1) developed in 2024 by experts at the Faculty of Education, Matej Bel University, to examine the development of children's life skills. They recorded teachers' professional activities in classroom practice and expressed their occurrence numerically using a frequency scale: 5 = certainly yes, 4 = yes, 3 = neither yes nor no, 2 = no, 1 = certainly no, 0 = do not know. In addition, they described situations in which the observed phenomenon occurred, with particular attention to the pedagogical strategies through which the teacher enacted these professional activities in specific classroom contexts. These written descriptions constituted the material for the qualitative analysis.

Table 1
Observation Sheet - Overview of Observed Professional Activities Within Four Life Skills

Life skills	Professional activities	5	4	3	2	1	0
Accepting behavior	The teacher supports acceptance and tolerant behavior of children through targeted activities.						
	Teacher notices and positively evaluates children's friendly behavior.						
	Classroom has a rule for children to maintain the order and well-being in the classroom.						
	Teacher applies an equal approach to education and upbringing in the classroom.						
Classroom behavioral regulation	Classroom has rules to manage children's behavior in learning						
	Teacher appreciates and verbally evaluates children's efforts.						
	Teacher appreciates and verbally evaluates children's perseverance.						
	Classroom has rules to tackle children's behavioral and learning problems.						
Work in a team	Teacher purposefully encourages children's regular cooperation.						
	Classroom has rules for work in groups.						
	Classroom has rules for open mutual communication.						
	Teacher purposefully encourages children's sense of humor.						
Self-assessment	The classroom has a regular method for children's self-assessment.						
	Teacher purposefully supports children's self-confidence by various activities.						
	Teacher purposefully builds children's responsibility for their own learning.						
	Teacher purposefully encourages children's flexibility and overall creativity.						

Note: Rating scale: 5 – certainly yes, 4 – yes, 3 – neither yes nor no, 2 – no, 1 – certainly no, 0 – do not know.

To ensure the trustworthiness and rigor of the qualitative findings, several strategies were implemented in accordance with international standards for educational research.

Prior to data collection, all observers (future teachers) underwent systematic methodological preparation. They were trained in the observation framework and practiced identifying analytical categories (e.g., behavioral regulation, inclusion) using video-recorded classroom situations to reduce inconsistencies in recording events.

The empirical material consisted of 137 written reflective notes based on direct observation of teaching, which allowed for broad coverage of different primary school classrooms. To minimize retrospective distortion, observation sheets were completed continuously during teaching, and reflections were prepared immediately after the end of the classroom observation, that is, after at least five consecutive school days of presence in the classroom as an observer. To increase reliability, the data analysis process included independent coding by two researchers (the observer trainers). After the initial coding phase, inter-coder agreement was assessed to identify discrepancies. These discrepancies were resolved through iterative consensus discussions until a consistent coding structure was achieved. Analytical integrity was further strengthened by the combined use of deductive categories derived from OECD and other international frameworks, together with subcategories that emerged from the empirical material. This ensured that the findings remained theoretically grounded while also being sensitive to new pedagogical patterns identified in classroom practice.

Data Analysis

The data were analyzed using qualitative content analysis combining deductive and inductive procedures. This approach was chosen because the study was based on four predefined analytical areas derived from the theoretical framework. At the same time, it identified pedagogical strategies and regulatory orientations of teachers that were not specified in advance. The use of this approach was also reflected in the design of the study as a qualitative follow-up to previously quantified empirical material (Čiliaková & Babiaková, 2025). The aim of the analysis was to deepen understanding through the qualitative interpretation of pedagogical strategies and broader regulatory orientations. Deductively, the analysis was guided by four predefined analytical areas derived from the theoretical framework and the structure of the observation sheet: acceptance and inclusion, classroom behavioral regulation, teamwork and communication, and self-assessment and responsibility for learning. Inductively, specific pedagogical strategies, subcategories, and patterns of classroom regulation were identified from the empirical material within these broader areas.

The analytical process proceeded in several stages. First, all reflections were read repeatedly to gain an overall understanding of the material. Second, meaning units relevant to the research questions were identified. Third, these units were openly coded with attention to recurring pedagogical actions, interactional patterns, and ways of regulating classroom life. Fourth, the codes were grouped into broader categories of pedagogical strategies within each of the four analytical areas. Finally, across these categories, broader interpretive patterns were identified and conceptualized as two regulatory orientations of classroom practice: participatory-preventive and directive-reactive.

The aim of the analysis was not to quantify the frequency of individual strategies, but to identify and interpret the range and character of pedagogical approaches through which teachers contributed to the formation of classroom community.

Research Results

The qualitative analysis identified a broad range of pedagogical strategies through which primary school teachers support classroom community. Across the predefined analytical dimensions, the findings reveal recurring patterns of pedagogical action and a dynamic interplay between participatory-preventive and directive-reactive orientations. As synthesized in Table 2, these observed pedagogical actions are distributed across the pedagogical areas of acceptance and inclusion, behavioral regulation, teamwork and communication, and children's responsibility for learning.

Table 2
Identified Pedagogical Strategies Across the Four Analytical Areas (N = 137)

Analytical area	Strategy category	Brief characteristic of observed practices
Acceptance and inclusion	Morning circles and rituals	Circle conversations, classroom meetings, sharing feelings and experiences
	Teacher as a model of respectful communication	Use of respectful language, humor, explanation of consequences, guidance toward tolerance
	Inclusive pedagogical practices	Task differentiation, individual support, sensitive work with diversity
	Immediate conflict resolution	Mediation, discussion without blaming, restorative responses
	Prosocial and developmental activities	Project-based, experiential, and community-oriented activities
	Formal emphasis on respect	Explicit reminders about politeness, respect, and classroom norms
	Verbal directive correction	Raised voice, brief reprimands, authoritative correction of behavior
Classroom behavioral regulation	Participatory rule-setting	Co-construction of rules, classroom agreements, children's participation
	Visualization of rules	Rules displayed visibly, use of symbols or posters
	Delegation of responsibility	Classroom duties, distribution of roles, shared responsibility
	Non-verbal regulatory signals	Raised hand, bell, agreed gestures, visual cues
	Positive motivational systems	Praise, symbolic rewards, points, encouragement
	Natural authority	Calm, consistent, and respectful regulation of behavior
	Unilaterally formulated rules	Rules imposed by the teacher without children's participation
	Sanction mechanisms	Notes, black marks, withdrawal of privileges, repetitive rewriting
	Public reprimands	Correction of misbehavior in front of the class
	Inconsistent rule enforcement	Formal existence of rules without systematic application
Teamwork and communication	Cooperative learning	Group work with shared tasks and role distribution
	Peer learning	Mutual help, explanation between classmates
	Classroom self-governance	Children's roles and responsibilities in organizing classroom life
	Spatial organization of the classroom	Semi-circle, clusters, carpet area, relaxation zones
	Project-based and shared activities	Longer-term collaborative tasks and common projects
	Active structuring of groups	Teacher intervention in group composition to support cooperation
	Predominantly frontal organization	Mainly teacher-led or individual work with limited cooperation
	Interruption of group work	Shift to individual work when cooperation fails or conflicts emerge

Self-assessment and responsibility for learning	Self-assessment activities	Pictograms, scales, self-evaluation techniques
	Reflective closing activities	Reflection on the lesson, day, or week
	Process-oriented feedback	Reflection on mistakes, feedback focused on progress
	Formative assessment	Portfolio work, individualized assessment, monitoring progress
	Suggesting one's own grade	Children's proposal of their own grade or evaluation
	Public evaluation of performance	Pointing out mistakes in front of the class
	Correction without alternatives	Insistence on one correct procedure without exploring alternatives
	Absence of reflection	Lack of space for feedback or self-reflection

The findings indicated that the selection and application of these strategies may reflect broader regulatory orientations of classroom practice, resulting in diverse patterns of classroom organization. Rather than representing fixed teacher types, these strategies function as interpretive orientations. Depending on their professional orientation, teachers may prioritize participatory-preventive methods that support children's autonomy, rely on directive-reactive interventions to maintain order, or situationally combine various approaches in response to the practical demands of the classroom. This highlights that building classroom community is a dynamic process shaped by the underlying tension between different regulatory orientations.

Strategies Supporting Acceptance and Inclusion

In the area of acceptance and inclusion, the material showed that teachers most often supported classroom community through relational and community-building practices. A particularly visible role was played by morning circles and similar shared rituals, which created space for children to speak about their experiences, listen to one another, and enter the lesson in a calm and socially connected atmosphere. The following description illustrates how such a routine functioned not only as an organizational opening, but also as a means of strengthening trust and mutual acceptance: "I conducted the observation on Monday. When I entered the classroom, I saw that the children were quietly waiting for the teacher and sitting at their desks. The class teacher then asked the children to sit on the carpet and began the lesson with a shared morning circle, during which the children greeted one another and shared their weekend experiences. In this way, a friendly atmosphere was created and mutual trust was strengthened. The children listened actively and accepted one another. She then asked the children to return quietly to their desks and asked the weekly classroom helpers to tell her who was absent. A pleasant silence continued in the classroom without any sign of tension. The teacher then informed the children about the course of the lesson and asked them to divide into groups."

Acceptance and inclusion were also supported through the teacher's own communicative style and through explicit modelling of respectful behavior. In several situations, teachers explained why respectful communication mattered, addressed inappropriate behavior through discussion rather than immediate sanction, and encouraged children to respond to one another with greater sensitivity. Inclusive support was especially visible when teachers worked with differences in learning needs, pace, or background. In these cases, participation was strengthened through adapted tasks, peer support, and deliberate efforts to ensure that no child was left outside the activity. The material also contained situations in which conflict was addressed immediately through dialogue. Rather than postponing tensions or reducing them to punishment, some teachers interrupted the activity, spoke with those involved, and guided the situation toward understanding and repair. Another important cluster of strategies consisted of prosocial and developmental activities extending beyond a single lesson. In some classrooms, the support

of acceptance and inclusion was embedded in broader class life through community meetings, experiential activities, projects, excursions, and social-emotional learning. One description summarized this broader pedagogical orientation as follows: "In addition to the activities I observed during the lesson, the teacher builds classroom community through a range of other activities. For example, she takes the children to a School in Nature every year, including when they were in the first grade. The class also participates in the Second Step program. She became involved in a grant project and obtained funding for the project Supporting Entrepreneurship and Soft Skills of Children, within which the children took part in experiential workshops focused on entrepreneurship and soft skills. She regularly organizes class meetings, various excursions and trips, as well as visits to the eco-centre, where children attend educational talks. In her teaching, she also uses experiential and inquiry-based methods."

The material also showed that respect was sometimes reinforced more explicitly through reminders about politeness and appropriate conduct during classroom interaction. At the same time, not all responses to social situations were relational in nature. Some descriptions pointed to more direct and authoritative correction, including raised voice or immediate reprimand. In this sense, acceptance and inclusion were supported mainly through strategies aimed at belonging, mutual respect, and supportive peer relations, but these practices were not entirely free of directive intervention. The coexistence of both tendencies pointed to a broader tension between inclusive intentions and authoritative regulation.

Strategies Supporting Classroom Behavioral Regulation

The material in the area of classroom behavioral regulation showed that regulation was often embedded in routines, shared expectations, and visible organizational structures. One of the clearest patterns concerned participatory rule-setting and the public presence of agreed classroom rules. In classrooms where regulation was more preventive in character, rules were not presented only as orders from the teacher, but as part of a collectively maintained framework for classroom life. This was reinforced when rules were written down, displayed, and symbolically endorsed by children: "In this classroom, there are established classroom rules, group-work rules, rules for break time, rules for playing football, and duties assigned to the weekly classroom helpers. All of these rules were created jointly by the children and the teacher, and the children actively participated in deciding which rules they wanted and were able to follow. The rules are written down and displayed in the classroom. The children signed them, thereby giving these rules additional importance."

Another prominent feature of the material was the use of non-verbal regulatory signals. Instead of interrupting the lesson through repeated verbal commands, some teachers relied on agreed gestures and visual cues that allowed order to be restored with minimal tension. A typical example was described in the following way: "The classroom became noisy. The teacher stopped speaking and raised her hand above her head, which the children noticed immediately, and those who were not talking raised their hands as well, following the teacher's example. Gradually, the whole classroom became quiet, and everyone had their hand raised. The teacher thanked the children. There was no need to silence the children verbally. They stopped talking on their own, and the teacher then had the space to explain the task."

Regulation was also supported through positive motivation, praise, and symbolic rewards, as well as through calm, respectful communication that relied on natural authority rather than overt pressure. In such situations, expectations were explained clearly, and children adjusted their behavior without visible escalation. Responsibility for maintaining classroom order was sometimes further distributed through classroom roles and duties, which connected behavioral regulation with accountability for shared classroom life.

At the same time, the material also documented more directive and reactive forms of regulation. In these situations, rules were presented as fixed requirements without children's participation, disruptions were addressed through direct verbal correction, and, in a smaller number of cases, teachers relied on sanctions such as notes or reprimands. What emerged from this contrast was not a simple opposition between "good" and "bad" practice, but a broader picture of classroom behavioral regulation as a field in which preventive and reactive logics coexisted. In some classrooms, participation, shared responsibility, and predictability dominated; in others, external control and immediate correction were more visible.

Strategies Supporting Teamwork and Communication

In the area of teamwork and communication, the material showed that cooperation was not limited to task completion, but functioned as an important social mechanism through which classroom participation and peer relations were shaped. Group work and cooperative learning created opportunities for shared problem-solving, discussion, and mutual help. These situations encouraged children not only to work together, but also to explain, negotiate, and respond to one another in ways that supported both learning and social connection. This kind of cooperation appeared in the material in descriptions such as the following: "Children worked in groups and discussed different ways of solving the task. A child explained the task to a classmate who did not understand it."

Teamwork was further supported through the use of classroom roles and responsibilities. When children were assigned roles within groups or within the wider organization of classroom life, this strengthened both accountability and participation in the class community. The organization of classroom space also mattered. In some classrooms, seating arrangements and layout were deliberately adjusted to make communication and cooperation easier, while in others the teacher actively intervened in group composition in order to balance interaction and prevent exclusion. These elements were sometimes described together as part of a broader collaborative orientation: "The teacher organizes group activities and projects that encourage children to help one another and share ideas. This approach not only supported teamwork, but also strengthened the children's ability to communicate and cooperate effectively, identify their strengths and weaknesses, and develop critical thinking. The teacher paid close attention to the development of individual strengths and supported all children. This approach led to greater motivation and self-confidence among the children. The desks were arranged so that children could easily work together in groups. The teacher changed the groups so that everyone had a chance to work with different classmates."

The analyzed material also included situations in which cooperation remained limited or fragile. In those cases, children worked mainly individually or within a more frontal teaching format, with little room for interaction. This suggests that teamwork in the observed classrooms functioned not only as a teaching method, but also as a social form whose maintenance required active pedagogical support. Where such support was weaker, collaborative interaction could easily give way to more controlled and teacher-directed formats.

Strategies Supporting Self-assessment and Responsibility for Learning

In the area of self-assessment and responsibility for learning, the material revealed strategies through which teachers created opportunities for reflection, feedback, and more active participation in evaluation. These strategies included reflective dialogue, visual self-assessment tools, formative feedback, and work with mistakes as part of the learning process. One recurring form of support was the deliberate creation of space for children to reflect on how they had worked, how they had felt during the lesson, and what they had learned. In

some classrooms, this reflection was embedded in a regular closing routine: "At the end of the lesson, the children remained on the carpet and the evaluation followed. The teacher evaluated the children's work and then asked them to assess how much they had enjoyed the lesson and how they had felt during it by giving a thumbs-up. It was again evident that the children were accustomed to engaging in self-assessment."

The use of mistakes as a resource for learning also appeared as an important strategy. Rather than treating error only as failure, some teachers encouraged children to identify mistakes themselves, understand them, and work with them constructively. This orientation is visible in the following description: "The teacher also analyzed mistakes together with the children who had made them. She taught them that a mistake is not something negative, but an opportunity to improve. She gave them the chance to identify the mistake themselves and supported them in learning how to work with it, correct it, and avoid it in the future."

The analyzed material further showed that some teachers invited children to participate more directly in evaluating their own performance, for example, by proposing their own grade or explaining how they understood their progress. In other classrooms, responsibility for learning was supported through formative assessment and portfolio work, which made it possible to monitor development over time and discuss it in a more process-oriented way.

At the same time, not all classrooms created such opportunities. Some descriptions pointed to situations in which reflection and self-assessment were largely absent, and evaluation remained predominantly teacher-centred. Overall, the findings indicate that strategies related to self-assessment and responsibility for learning played an important role in supporting autonomy, but their implementation varied considerably across classrooms. In some settings, reflective and formative approaches were clearly present; in others, evaluation remained more summative and externally controlled.

Regulatory Orientations of Classroom Practice

Across the four analytical areas, the identified strategies revealed broader recurring patterns in the regulation of classroom life. Although individual strategies differed in form and function, they tended to cluster around two broader regulatory orientations. The first orientation was participatory-preventive, characterized by children's involvement, relationship-building, shared responsibility, reflection, and support for internal regulation of behavior. The second orientation was directive-reactive, characterized by unilateral decision-making, external behavioral control, sanctions, and corrective responses to disruptions or insufficient performance.

These orientations did not represent fixed types of teachers; rather, they functioned as interpretive patterns through which it was possible to understand the observed classroom practices. In many reflections, both orientations appeared in combination, which suggests that teachers moved situationally on a spectrum between participatory and directive forms of regulation.

Table 3 summarizes the characteristic features of both orientations and illustrates their relationship to the identified pedagogical strategies.

Table 3*Regulatory Orientations Identified Across Classroom Community Building Practices*

Regulatory orientation	Characteristic features	Illustrative pedagogical strategies
Participatory-preventive orientation	Classroom management based on children's participation, relationship building, support for internal regulation of behavior, reflection and the development of responsibility.	Morning circles and rituals; teacher as a model of respectful communication; inclusive pedagogical practices; immediate conflict resolution; prosocial activities; participatory rule-setting; delegation of responsibility; non-verbal regulatory signals; positive motivational systems; natural authority; cooperative learning; peer learning; classroom self-governance; self-assessment activities; reflective closing activities; process-oriented feedback; formative assessment.
Directive-reactive orientation	Classroom management based on external behavioral control, unilateral rule-setting, sanction mechanisms and performance-oriented evaluation.	Verbal directive correction; unilateral rule formulation; sanction mechanisms; public reprimands; inconsistent rule enforcement; predominantly frontal situations; interruption of group work; public evaluation of performance; correcting answers without offering alternatives; absence of reflection.

Discussion

The findings addressed the three research questions. First, with regard to RQ1, the analysis showed that primary school teachers were described as using a broad repertoire of pedagogical strategies to build classroom community in everyday classroom practice. These strategies ranged from relational, inclusive, and autonomy-supportive practices to more directive and corrective forms of behavioral regulation. Second, in response to RQ2, these strategies were manifested across four interrelated analytical areas: acceptance and inclusion, classroom behavioral regulation, teamwork and communication, and self-assessment and responsibility for learning. Third, with regard to RQ3, the analysis indicated that, across these four areas, the identified strategies clustered around two broader regulatory orientations of classroom practice, conceptualized here as participatory-preventive and directive-reactive. Taken together, these findings suggest that classroom community-building is shaped not by isolated techniques alone, but by pedagogical strategies rooted in teachers' individual conceptions of teaching, through which participation, relationships, behavior, and learning are regulated in everyday classroom practice. These results provide the basis for the following interpretation.

In the area of acceptance and inclusion, the findings indicate that teachers often supported classroom community through relational practices such as morning circles, respectful communication, conflict mediation, and inclusive support for diverse children's needs. These strategies are consistent with research emphasizing the importance of teacher – child relationships and emotionally supportive classroom environments for children's engagement and behavior (Aldrup et al., 2020; Wang & Degol, 2020). At the same time, the reflections also pointed to directive forms of behavioral correction, suggesting that inclusive intentions may coexist with authoritative responses to classroom tensions. Rather than interpreting these approaches as mutually exclusive, the findings suggest that teachers combine them situationally in response to the practical demands of classroom life.

A similar tension emerged in the area of classroom behavioral regulation. Participatory rule-setting, delegation of responsibility, and the use of non-verbal signals can be understood as strategies that support the gradual internalization of norms and the development of children's self-regulation. This interpretation corresponds with research on self-regulated learning and the

pedagogical importance of transferring regulatory responsibility to learners (Panadero et al., 2019; Panadero, 2023). By contrast, sanction mechanisms, public reprimands, and unilateral rule enforcement reflect a more behaviorally oriented model of classroom behavioral regulation in learning based on external control. The coexistence of these approaches suggests that classroom behavioral regulation in primary education is not best understood as a stable teaching style, but rather as a dynamic regulatory field in which preventive and reactive strategies are combined.

In the area of teamwork and communication, the findings highlight the importance of cooperative learning, peer support, and the organization of classroom roles and space. These strategies suggest that teamwork functions not only as a means of improving learning outcomes, but also as a mechanism for shaping social participation and classroom belonging. This is in line with studies that view social interaction as a core component of both learning and classroom climate (Gillies, 2016; Vančíková et al., 2025). At the same time, the empirical material also showed that collaborative formats could be interrupted or replaced by frontal forms of teaching when difficulties arose. This may indicate that while teachers recognize the value of teamwork, sustaining collaborative interaction in everyday practice remains demanding.

The findings were particularly notable in the area of self-assessment and responsibility for learning. Reflective closing activities, self-assessment techniques, portfolio work, and process-oriented feedback indicate that some teachers created space for children to reflect on their progress, interpret mistakes, and assume greater responsibility for learning. These practices are consistent with current views of formative assessment and feedback as tools that support reflection, autonomy, and deeper learning (Panadero et al., 2023; Cumhur, 2022; Metcalfe, 2017; Görtzen et al., 2025). At the same time, some reflections described assessment as predominantly teacher-controlled and summative. This contrast again supports the interpretation that classroom community-building is connected to broader regulatory principles that shape whether children are positioned as active participants in learning or mainly as recipients of teacher-led evaluation.

From the perspective of teacher education, the findings suggest that building classroom community requires more than the use of isolated methods or techniques. It also depends on how teachers understand regulation, authority, participation, and children's agency in everyday classroom practice. In this sense, the identified regulatory orientations may offer a useful framework for reflecting on teaching practice. They make visible not only supportive and inclusive strategies, but also those patterns of interaction that may limit children's participation, reflection, and autonomy.

Taken together, the findings suggest that building classroom community in primary education is not a one-dimensional pedagogical task, but a dynamic process shaped by how teachers balance behavioral regulation, participation, cooperation, and reflection. The concept of regulatory orientations may therefore provide a useful analytical lens for further research on classroom practice and for the professional preparation of teachers.

Conclusions and Implications

This study showed that classroom community in primary education is built through a differentiated repertoire of pedagogical strategies. Its main contribution lies in demonstrating that these strategies can be interpreted through two distinct regulatory orientations of classroom practice: participatory-preventive and directive-reactive. The observer reflections revealed clear differences between these orientations and suggested that they shape the ways in which pupils' life skills are supported and regulated in everyday classroom practice. The findings also indicate that building classroom community is not limited to relational support alone, but is closely connected to teachers' everyday decisions regarding acceptance and inclusion, classroom behavioral regulation, teamwork and communication, and self-assessment and responsibility for learning.

The study also has several limitations. The empirical material consisted of written reflections produced by trained future teachers. Therefore, the findings are based on mediated interpretations of classroom practice rather than direct recordings of pedagogical interaction. Although the observers were methodologically prepared, their reflections may have been shaped by selective attention, prior beliefs, and varying levels of interpretive sensitivity. The research was conducted in the context of Slovak primary education, which limits the direct transferability of the findings to other educational settings. Future research could build on these findings by combining qualitative content analysis with direct classroom observation, video-based analysis, or interviews with teachers. It would also be useful to explore more closely how different regulatory orientations relate to classroom climate, children's engagement, and the development of inclusive learning environments. The study also did not systematically examine differences across grade levels, and detailed contextual characteristics such as urban–rural location. Nevertheless, the concept of regulatory orientations may serve as a useful interpretive framework for further international research on classroom practice, as well as for the professional preparation and continuing professional development of primary teachers in other Central European countries.

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the Grant KEGA No. 006UMB-4/2026.

Declaration of Interest

The authors declare no competing interest.

Data availability statement

The research data supporting this study are available from the first author, Ružena Čiliaková, upon reasonable request.

Ethics statement

All data were processed anonymously and in accordance with ethical principles of educational research. The written reflections did not contain identifying information about individual children or teachers. Participation in the course assignment from which the material was drawn followed standard educational procedures, and all excerpts presented in the study are fully anonymized.

References

- Aldrup, K., Carstensen, B., Köller, M. M., & Klusmann, U. (2020). Measuring teachers' social-emotional competence: Development and validation of a situational judgment test. *Frontiers in Psychology, 11*, Article 892. <https://doi.org/10.3389/fpsyg.2020.00892>
- Čiliaková, R., & Babiaková, S. (2025). Building a classroom community in primary education: Findings from student observations. *The New Educational Review, 80*, 187–199. <https://repo.umb.sk/handle/123456789/877>
- Can, M., Özkan, H., & Bozbayındır, F. (2025). Teachers' moral capital: Level, determinants and development strategies. *Problems of Education in the 21st Century, 83*(3), 282–305. <https://doi.org/10.33225/pec/25.83.282>

- Cumhur, F. (2022). Pre-service teachers' approaches to guiding students in problem solving process. *Problems of Education in the 21st Century*, 80(1), 144–161. <https://doi.org/10.33225/pec/22.80.144>
- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97–140. <https://doi.org/10.1080/10888691.2018.1537791>
- Domitrovich, C. E., Durlak, J. A., Staley, K. C., & Weissberg, R. P. (2017). Social-emotional competence: An essential factor for promoting positive adjustment and reducing risk in school children. *Child Development*, 88(2), 408–416. <https://doi.org/10.1111/cdev.12739>
- Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child Development*, 82(1), 405–432. <https://doi.org/10.1111/j.1467-8624.2010.01564.x>
- Gillies, R. M. (2016). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education*, 41(3), Article 3. <https://doi.org/10.14221/ajte.2016v41n3.3>
- Goldberg, J. M., Sklad, M., Elfring, T., Schreurs, K. M. G., Bohlmeijer, E. T., & Clarke, A. M. (2019). Effectiveness of interventions adopting a whole school approach to enhancing social and emotional development: A meta-analysis. *European Journal of Psychology of Education*, 34, 755–782. <https://doi.org/10.1007/s10212-018-0406-9>
- Görtzen, J. J. H., Stollman, S. H. M., Schellings, G. L. M., Vermunt, J. D., & Nieveen, N. M. (2025). Promoting students' reflection through process-oriented feedback: Teachers' conceptions, practices and learning needs. *Studies in Educational Evaluation*, 86, Article 101483. <https://doi.org/10.1016/j.stueduc.2025.101483>
- Greenberg, M. T., & Kusché, C. A. (2006). Building social and emotional competence: The PATHS curriculum. In S. R. Jimerson & M. J. Furlong (Eds.), *Handbook of school violence and school safety: From research to practice* (pp. 395–412). Lawrence Erlbaum Associates.
- Immordino-Yang, M. H., Darling-Hammond, L., & Krone, C. (2019). Nurturing nature: How brain development is inherently social and emotional, and what this means for education. *Educational Psychologist*, 54(3), 185–204. <https://doi.org/10.1080/00461520.2019.1633924>
- Metcalfe, J. (2017). Learning from errors. *Annual Review of Psychology*, 68, 465–489. <https://doi.org/10.1146/annurev-psych-010416-044022>
- OECD. (2021). *Beyond academic learning: First results from the survey of social and emotional skills*. OECD Publishing.
- Panadero, E. (2023). Toward a paradigm shift in feedback research: Five further steps influenced by self-regulated learning theory. *Educational Psychologist*, 58(3), 193–204. <https://doi.org/10.1080/00461520.2023.2223642>
- Panadero, E., Broadbent, J., Boud, D., & Lodge, J. M. (2019). Using formative assessment to influence self- and co-regulated learning: The role of evaluative judgement. *European Journal of Psychology of Education*, 34(3), 535–557. <https://doi.org/10.1007/s10212-018-0407-8>
- Parween, A., & Raza, M. M. (2025). Social and emotional learning (SEL) in teacher preparation: Building a foundation for holistic education. *Journal of Advance and Future Research*, 3(12), 460–465. <https://doi.org/10.13140/RG.2.2.12101.51681>
- Porubský, Š. (2024). *Koncepčné zmeny v štátnom vzdelávacom programe [Conceptual changes in the state educational program]*. NIVaM. <https://vzdelavanie21.sk/wp-content/uploads/2024/11/Koncepcne-zmeny.pdf>
- Rochovská, I. (2026). Individual teaching philosophy of parents of homeschooled children in comparison with primary school teachers. *Pedagogika-Pedagogy*, 98(2), 217–228. <https://doi.org/10.53656/ped2026-2.04>
- Taylor, R. D., Oberle, E., Durlak, J. A., & Weissberg, R. P. (2017). Promoting positive youth development through school-based social and emotional learning interventions: A meta-analysis of follow-up effects. *Child Development*, 88(4), 1156–1171. <https://doi.org/10.1111/cdev.12864>

- Vančíková, K., Čiliaková, R., & Hušlová Orságová, M. (2025). Conceptualizations of inclusive schooling by pre-service teachers in Slovakia. *Problems of Education in the 21st Century*, 83(5), 689–704. <https://doi.org/10.33225/pec/25.83.689>
- Wang, M.-T., Degol, J. L., Amemiya, J., Parr, A., & Guo, J. (2020). Classroom climate and children's academic and psychological well-being: A systematic review and meta-analysis. *Developmental Review*, 57, Article 100912. <https://doi.org/10.1016/j.dr.2020.100912>

Received: March 24, 2026

Revised: May 05, 2026

Accepted: May 29, 2026

Cite as: Čiliaková, R., & Babiaková, S. (2026). Teachers' strategies for building classroom community in Slovak primary education. *Problems of Education in the 21st Century*, 84(3), 382–397. <https://doi.org/10.33225/pec/26.84.382>

Ružena Čiliaková
(Corresponding author)

PhD, Assistant Professor, Faculty of Education, Matej Bel University, Ružová 13, 974 11 Banská Bystrica, Slovakia.
E-mail: ruzena.ciliakova@umb.sk
ORCID: <https://orcid.org/0000-0001-5176-6768>

Simoneta Babiaková

PhD, Associate Professor, Faculty of Education, Matej Bel University, Ružová 13, 974 11 Banská Bystrica, Slovakia.
E-mail: simoneta.babiakova@umb.sk
ORCID: <https://orcid.org/0000-0002-4038-7006>



CROSS-CULTURAL COMPETENCE AND SKILLS IN HIGHER EDUCATION: A GENERALIZED LINEAR MODELING APPROACH TOWARDS A CULTURE-BASED EXTENSION PROGRAM

Mary Grace O. Gallego

Sultan Kudarat State University, Philippines

E-mail: marygracegallego@sksu.edu.ph

Abstract

Despite increasing emphasis on crosscultural competence and 21stcentury skills in higher education, most of the studies have relied on descriptive or correlational methods, limiting predictive insights. This study addressed that gap by developing a Generalized Linear Model (GLM) to explain how 21stcentury skills influence crosscultural competence among students, serving as the basis for a culturebased extension program. Data from 319 respondents were analyzed using descriptive statistics and GLM. Findings revealed moderate levels of both crosscultural competence and 21stcentury skills, suggesting that while foundational abilities exist, they remain underdeveloped. Communication and collaboration emerged as the strongest predictors of crosscultural competence, underscoring the importance of interactiondriven skills. The Gamma loglink model provided the best fit, confirming that the relationship is nonlinear, contextdependent, and shaped by uneven learning experiences. The study concludes that crosscultural competence is a multidimensional construct shaped by cognitive, behavioral, and affective domains, and strengthened through interaction, experience, and reflection. Anchored in constructivist and intercultural competence theories, the results highlight the need for experiential, collaborative, and culturally responsive learning environments. These findings provide empirical support for a culturebased extension program designed to enhance students' readiness for global and multicultural engagement.

Keywords: cross-cultural skills, competency skills, higher education, generalized linear modeling, extension program

Introduction

The Philippine higher education sector has consistently identified both cross-cultural competence and 21st-century skills as being central to globalization, internationalization, and digital transformation. Therefore, it was effective in assisting learners to adapt to diverse and increasingly knowledge-based environments (Pacione, 2011; Hattie, 2009; Johnson & Johnson, 2009; Robinson, 2011) c[Reviewer1.1]ross-cultural competence emphasizes cultural awareness, openness and a recognition of cultural difference as necessary for meaningful interactions between different cultures in a multicultural learning environment within higher education (Deardorff, 2006; Chen & Starosta, 2000). Furthermore, the majority of higher education students have been shown to have moderately high levels of intercultural sensitivity, particularly in relation to interacting with people from other cultures and demonstrating respect towards their culture; this suggests that through formal education and experience gained whilst engaging in multiculturalism, these competencies can be developed.

Recent studies highlighted the integration of culturebased and inclusive pedagogies in alignment with global education agendas such as Sustainable Development Goal 4,

which advocated equitable, culturally responsive, and quality education (GonzálezPérez & RamírezMontoya, 2022; UNESCO, 2017). Higher education institutions increasingly adopted flexible, technologymediated, and globally oriented learning environments, where digital literacy and global connectivity expanded opportunities for intercultural engagement and collaborative learning (Greenhow & Lewin, 2016). Within this context, crosscultural competence was conceptualized as a multidimensional construct comprising cognitive (knowledge), behavioral (skills), and affective (attitudes) components, shaped by instructional practices and learners' sociocultural experiences (Chen & Hu, 2023; Deardorff, 2006).

Despite these advances, notable gaps persisted. Existing studies predominantly employed descriptive and correlational methods, which limited analytical insight into the dynamic interactions between crosscultural competence and 21stcentury skills. Although students often reported high competency levels, enduring challenges, including limited selfawareness, insufficient skillbased education, career uncertainty, and cultural disconnectedness, continued to impede development. Institutional barriers such as weak policies, fragmented program integration, and inadequate monitoring further constrained the operationalization of culturebased education (Baron, 2023; Pelayo et al., 2025). Theoretically, few studies modeled predictive relationships among competence variables, resulting in fragmented understandings of their impact on educational outcomes. Practically, the absence of statistical modeling restricted the design of sustainable, evidencebased extension programs. These limitations underscored the need for analytical approaches that moved beyond description toward explanation and prediction.

Addressing these gaps, the present study examined crosscultural competence and 21stcentury skills among higher education students using a Generalized Linear Modeling (GLM). Specifically, it analyzed the predictive relationships among the 4Cs and dimensions of crosscultural competence, while considering contextual challenges (e.g., selfawareness deficits, skill gaps, cultural disconnectedness) and opportunities (e.g., digital literacy, global connectivity). Methodologically, GLM provided a statistical approach to test theoretical assumptions, model variable interactions, and generate predictive insights from a commonly utilized correlation analysis. The study ultimately sought to inform the development of empirically grounded, culturebased extension programs. This research contributed both theoretically and practically. Theoretically, it advanced the literature by integrating crosscultural competence and 21stcentury skills within a predictive modeling framework, addressing the lack of advanced statistical analyses in prior work. Unlike studies that primarily described competency levels (Pelayo et al., 2026), this study provided a nuanced account of how competencies interacted and influenced one another. Practically, it supported the design of datadriven, culturebased enhancement programs tailored to higher education institutions. By bridging the gap between assessment and program design, the study responded to the urgent need for structured, evidencebased interventions that fostered culturally responsive, inclusive, and skilloriented education. In doing so, it strengthened crosscultural competence frameworks and advanced educational practice in contemporary higher education.

Research Problem

Higher education increasingly emphasizes cross-cultural competence and 21st-century skills, yet their interaction and influence on student outcomes remain poorly understood. Evidence suggests students demonstrate only moderate proficiency in both domains, underscoring a gap between foundational knowledge and advanced application. Existing studies, largely descriptive and correlational, provide limited insight into predictive relationships, resulting in a fragmented understanding of how the 4Cs collectively shape cross-cultural competence within specific institutional contexts. Moreover, constraints such as limited experiential

learning, uneven instructional practices, and inadequate institutional support hinder students' engagement and confidence in intercultural settings. The absence of predictive, data-driven models further restricts the design of targeted interventions. To address these gaps, advanced analytical approaches, particularly Generalized Linear Modeling, are needed to clarify these relationships and establish an empirical foundation for a culture-based enhancement program.

Research Focus

This study described the pedagogical approaches in higher education and determined its relationship to student competencies, with particular attention to cross-cultural competence and the 21st-century skills of critical thinking, communication, collaboration, and creativity. It examined how these competencies are manifested, how variations influence student development, and where gaps emerge between perceived competence and actual skill integration. Challenges in practical application within institutional contexts were also identified. To move beyond descriptive accounts, the study employed Generalized Linear Modeling to generate predictive, empirical evidence that can inform the design of a culture-based enhancement program, strengthen competency-based instruction, and ultimately improve student outcomes in higher education.

Research Aim

This study intended to generate a Generalized Linear Model that best illustrates the relationship between cross-cultural competence and 21st-century competency skills among higher education students as a basis for a culture-based enhancement program. Specifically, it sought to answer the following questions:

1. What was the perceived assessment of the respondents on cross-cultural competence in terms of the following dimensions:
 - 1.1 interaction engagement;
 - 1.2 respect for cultural differences;
 - 1.3 interaction confidence; and,
 - 1.4 interaction attentiveness?
2. What was the perceived assessment of the respondents on 21st-century competency skills in terms of the following domains:
 - 2.1 critical thinking;
 - 2.2 communication;
 - 2.3 collaboration; and,
 - 2.4 creativity?
3. Which among the significant factors of cross-cultural competence affect the 21st-century competency skills of higher education students?
4. What Generalized Linear Model best fits to illustrate the relationship between cross-cultural competence and 21st-century competency skills among higher education students?
5. What culture-based extension program may be proposed based on the results of the study?

Research Methodology

Design

This study used a quantitative descriptive-correlational design to assess and describe the relationship between cross-cultural competence and 21st-century skills among higher education students. Descriptive statistics, such as weighted mean and standard deviation, were used to determine the students' levels of competence in intercultural dimensions, including interaction engagement, respect for cultural differences, interaction confidence, and attentiveness, as well as in the 21st-century skill areas of critical thinking, communication, collaboration, and creativity.

To ascertain the relationship between these variables, Generalized Linear Modeling (GLM) was applied. This allowed the study to determine the predictive relationships and handle data with non-normal distributions (Creswell, 2018). Different model specifications, such as Gaussian and Gamma log link models, were compared using goodness-of-fit measures including AIC, BIC, and deviance to determine the most appropriate model. Data were collected through a structured Likert-scale survey, which provided a reliable basis for analyzing how 21st-century skills influence cross-cultural competence. By combining descriptive analysis and predictive modeling, the study developed an evidence-based community extension program that may support the creation of a culture-based enhancement program (Hero, 2026).

Sample

This study used simple random sampling to give students from different academic programs and year levels an equal chance of being selected, helping reduce selection bias and improve the representativeness of the participants (Creswell, 2018). The research population consisted of 1850 undergraduate students enrolled in all the offered programs in one state university in Sultan Kudarat during the conduct of the study. The respondents came from different academic programs and from first- to fourth-year levels, ensuring that the sample reflected the diversity of the student population within the institution. A total of 319 undergraduate students participated in the study. The sample size was calculated using Yamane's (1967) formula, a widely accepted method for determining an appropriate sample size in survey research. Using a 5% margin of error, the formula ensured that the number of respondents was sufficient to produce reliable data and support valid statistical conclusions.

After identifying the required sample size, proportional allocation was applied to determine how many respondents would come from each academic program and year level. The participants were then selected through simple random sampling within each group. This procedure ensured that all students had an equal opportunity to participate while maintaining fair representation of the university population. The respondents were officially enrolled students with adequate exposure to academic and intercultural learning experiences. This enabled the study to provide meaningful responses to the study variables. The combination of simple random sampling and proportional allocation strengthened the credibility, reliability, and representativeness of the findings. These procedures helped ensure that the results accurately reflected the experiences of the student population within the university and provided a sound basis for making valid conclusions aligned with the study's quantitative research design (Creswell, 2018).

Instrument and Procedures

The study utilized a self-administered survey questionnaire to measure crosscultural competence and 21stcentury skills among students in a state university in Sultan Kudarat.

The instrument was developed from an extensive review of related literature and anchored on established frameworks of intercultural competence and 21st-century skills, following a structured quantitative survey design. It consisted of two parts: the first assessed cross-cultural competence across four dimensions, such as interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. While the second measured 21st-century skills based on the “4Cs”: critical thinking, communication, collaboration, and creativity. All items were rated on a 5-point Likert scale (5 = Strongly Agree to 1 = Strongly Disagree), allowing respondents to indicate their level of agreement with each statement.

To ensure validity, the instrument underwent expert review by specialists in education, research, and intercultural studies, focusing on content and face validity. Revisions were made to improve clarity and alignment with the study constructs. Reliability was established through a pilot test with respondents outside the target population, and internal consistency was confirmed using Cronbach’s alpha, which yielded acceptable coefficients ($\alpha \geq 0.7$) (Taber, 2018). Specifically, cross-cultural competence items achieved $\alpha = 0.85$, while 21st-century skills items achieved $\alpha = 0.89$. These results indicated strong reliability, affirming the instrument’s suitability for data collection and for generating inputs to the Generalized Linear Modeling analysis.

Data Analysis

The data gathered from the survey were analyzed using appropriate descriptive and inferential statistical techniques. Statistical analysis was performed using software such as JAMovi to ensure accuracy, efficiency, and reproducibility of results. Descriptive statistics, including weighted mean and standard deviation, were used to determine the level of cross-cultural competence and 21st-century competency skills among the respondents. These measures provided a summary of central tendency and variability, allowing the study to establish the overall patterns and distribution of responses across the identified dimensions. Prior to inferential analysis, the Shapiro–Wilk test was conducted to assess the normality of the data. This step determined whether the data met the assumptions of normal distribution and guided the selection of appropriate statistical models. Given that perception-based data, it exhibited a non-normal distribution, this justified the use of more flexible analytical approaches such as Generalized Linear Modeling (GLM).

To examine the relationships between variables, bivariate correlation analysis was initially conducted to identify significant associations between 21st-century competency skills and cross-cultural competence. This provided a preliminary understanding of the direction and strength of relationships among the variables. Building on this, Generalized Linear Modeling (GLM) was employed as the primary inferential technique to determine the predictive influence of 21st-century competency skills (critical thinking, communication, collaboration, and creativity) on cross-cultural competence. Both Gaussian and Gamma log-link models were tested to compare alternative distributional assumptions and identify the most appropriate model for the data. Model fit was evaluated using statistical indices such as Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), deviance, and log-likelihood, where lower values indicated better model fit. The selection of the best-fitting model was based on goodness-of-fit results and theoretical alignment, ensuring that the chosen model accurately represented the structure of the data and the nature of the variables. This analytical approach allowed the study to move beyond simple association and establish a predictive model that explains how 21st-century competency skills influence cross-cultural competence.

Ethical Considerations

The study adhered to established ethical standards for research involving human participants. Institutional approval was obtained before data collection, and respondents were fully informed of the study’s purpose, scope, and procedures. Informed consent ensured voluntary participation and the right to withdraw at any time. Compliance with the Data Privacy Act of 2012 (Republic Act No. 10173) was observed by safeguarding personal information, maintaining anonymity, and treating all data with strict confidentiality. Care was taken to avoid physical, psychological, or emotional harm, with survey items designed to be nonintrusive and free from coercion or deception. Ethical principles of respect, beneficence, and justice guided the process. The researcher also acknowledged the responsible use of AI tools (e.g., ChatGPT) for language refinement and organization, limited to improving clarity without replacing critical analysis or interpretation. All AI-assisted outputs were reviewed for accuracy and originality, sources were properly cited, and data were securely stored with plans for appropriate disposal after study completion.

Research Results

Cross-cultural competence has become an essential skill in higher education, particularly in increasingly diverse and multicultural learning environments. Understanding how students perceive and respond to cultural differences is important in determining their readiness to engage effectively with individuals from various cultural backgrounds. In this study, cross-cultural competence was examined through the dimensions of interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. The results are presented in Table 1.

Table 1
Descriptive Analysis of the Cross-Cultural Competence of University Students

Indicators	$\bar{X}_w$	σ	CV	η^2	Interpretation
Interaction Engagement	3.41	0.89	0.21	0.00	Moderate
Respect for Cultural Differences	3.32	0.66	0.18	0.00	Moderate
Interaction Confidence	3.49	0.87	0.20	0.01	Moderate
Interaction Attentiveness	3.53	0.76	0.22	0.00	High
Average	3.44	0.76	0.19		Moderate

The descriptive analysis presented in Table 1 analyzed the cross-cultural competence of university students in terms of interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. The aim of this analysis was to determine how students perceive and respond to cultural diversity within their academic and social interactions.

As shown in Table 1, the respondents demonstrated a moderate level of cross-cultural competence, reflected in the overall mean score of 3.44 with a standard deviation of 0.76. The coefficient of variation, which is equal to 0.19, indicates that the responses were relatively consistent across participants, suggesting that students shared similar perceptions and experiences regarding intercultural interaction. Among the four dimensions, interaction attentiveness obtained the highest mean score, interpreted as high. On the other hand, interaction engagement, respect for cultural differences, and interaction confidence were all interpreted as moderate.

The findings suggest that students are generally aware of and sensitive to cultural differences, particularly in terms of being attentive and respectful during intercultural interactions. Many of the respondents appear to be careful and observant when communicating with people from different cultural backgrounds. However, the moderate ratings in engagement and confidence indicate that students may still feel hesitant or uncertain when actively participating in intercultural exchanges. While they show openness toward diversity, they may not yet feel fully comfortable expressing themselves or interacting confidently in multicultural settings. The low coefficients of variation across all indicators further suggest that cross-cultural competence is a commonly shared characteristic among the respondents. At the same time, the results of the Shapiro–Wilk test revealed that the data were not normally distributed, implying that students’ experiences and levels of intercultural exposure may differ depending on their background, social interaction, and learning environment.

The findings support the idea that cross-cultural competence develops through experience, interaction, and exposure to diverse environments. The results also suggest that awareness alone is not enough to strengthen intercultural competence. Students need more opportunities to engage in meaningful cultural interactions that can help build their confidence, communication skills, and active participation in multicultural settings. These findings provide support for the development of culture-based educational interventions and extension programs that promote experiential learning, collaboration, and intercultural engagement.

In today’s rapidly changing and globally connected society, 21st-century competency skills play an important role in preparing students for academic, professional, and intercultural engagement. Skills such as critical thinking, communication, collaboration, and creativity are considered essential in helping learners adapt to complex and diverse environments. In this study, the level of students’ 21st-century competency skills was examined across these four domains, and the results are presented in Table 2.

Table 2
Descriptive Analysis of the 21st-Century Competency Skills of University Students

Indicators	$\bar{X}_w$	S	CV	η^2	Interpretation
Critical Thinking	3.63	0.74	0.20	0.00	Moderate
Communication	3.70	0.66	0.18	0.00	Moderate
Collaboration	3.54	0.69	0.19	0.00	Moderate
Creativity	3.57	0.70	0.20	0.00	Moderate
Average	3.61	0.70	0.20		High

The descriptive analysis presented in Table 2 described and analyzed the 21st-century competency skills of university students in terms of critical thinking, communication, collaboration, and creativity. This analysis aimed to determine the extent to which students possess the competencies needed to function effectively in academic, professional, and culturally diverse environments.

As shown in Table 2, the respondents demonstrated a generally favorable level of 21st-century competency skills, with an overall mean score of 3.61 and a standard deviation of 0.70, interpreted as high. The coefficient of variation, which is equal to 0.20, indicates relatively low variability in responses, suggesting that students shared similar perceptions regarding their competency skills across the different domains assessed. Among the indicators, communication obtained the highest mean score, followed by critical thinking, creativity, and collaboration. Although the overall results were favorable, all indicators were interpreted as moderate.

The findings suggest that students already possess the basic competencies expected in 21st-century learning, particularly in expressing ideas and communicating effectively with others. The high rating in communication may indicate that students are generally comfortable sharing ideas, participating in discussions, and engaging in academic interactions. However, the lower rating in collaboration suggests that students may still encounter difficulties in teamwork, shared decision-making, and collective problem-solving. Similarly, the moderate ratings in critical thinking and creativity imply that while students demonstrate these skills to some extent, there is still a need to strengthen their ability to apply them in more complex, real-life, and interdisciplinary situations.

The consistently low coefficients of variation across all domains further indicate that these competencies are commonly experienced among the respondents, possibly reflecting similarities in their academic exposure and learning experiences. Nevertheless, the moderate ratings across the indicators point to areas that still require improvement, particularly in promoting deeper critical inquiry, innovative thinking, and collaborative engagement. In addition, the results of the Shapiro–Wilk test revealed that the data were not normally distributed, suggesting that students' competency levels may vary depending on their learning experiences, exposure to diverse environments, and individual participation in academic and social activities. This finding also supports the use of flexible inferential techniques such as Generalized Linear Modeling in the succeeding analyses.

The findings suggest that students possess emerging 21st-century competency skills, although these competencies are still developing and may not yet be fully applied in more demanding or real-world contexts. The results highlight the importance of providing students with more meaningful and experience-based learning opportunities that encourage critical thinking, creativity, collaboration, and effective communication. The findings also support the view that 21st-century skills are dynamic and continuously shaped by instructional practices, social interaction, and experiential learning. Hence, the results provide support for the development of culture-based educational interventions and enhancement programs that integrate collaborative learning, authentic problem-solving activities, and interdisciplinary engagement to strengthen students' competencies in a globalized and culturally diverse society.

Generalized Linear Model Using Gaussian Log-Link in Examining the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

A Generalized Linear Model (GLM) using the Gaussian distribution with a log-link function was employed to examine the relationship between 21st-century competency skills and cross-cultural competence. This approach was utilized to determine which competency skills significantly predict students' cross-cultural competence across diverse cultural contexts.

Table 3
Parameter Estimates (Coefficients)

Name	Estimate	SE	95% Confidence Intervals		z	p
			Lower	Upper		
(Intercept)	1.002	0.009	1.121	1.142	153.600	< .001
Interaction Engagement	0.073	0.014	0.043	0.079	6.880	< .001*
Respect for Cultural Differences	0.078	0.010	0.040	0.089	6.553	< .001*
Interaction Confidence	0.091	0.009	0.058	0.109	8.280	< .001*
Interaction Attentiveness	0.02	0.006	-0.000	0.043	2.869	.080

The results of the Generalized Linear Model (GLM) using the Gaussian log-link revealed that the different dimensions of cross-cultural competence were associated with students' 21st-century skills in varying ways. The findings showed that students who demonstrated stronger intercultural engagement, greater respect for cultural differences, and higher confidence in intercultural interactions also tended to exhibit stronger 21st-century competencies. These results suggest that students who are more comfortable interacting with individuals from diverse cultural backgrounds are more likely to communicate effectively, collaborate with others, and apply critical thinking in different learning situations.

Among the identified dimensions, interaction confidence emerged as the strongest predictor of 21st-century skills. This finding highlights the importance of self-assurance and comfort in intercultural communication, suggesting that students who feel more confident in engaging with culturally diverse individuals are also more capable of participating actively in collaborative and intellectually demanding environments. Likewise, interaction engagement and respect for cultural differences also showed meaningful contributions, indicating that openness to diversity and active participation in intercultural experiences play an important role in strengthening students' competencies needed in contemporary education and society.

In contrast, interaction attentiveness did not demonstrate a statistically significant influence on students' 21st-century skills. Although students may be attentive and aware during intercultural interactions, the findings suggest that attentiveness alone may not be sufficient to strengthen competencies such as communication, collaboration, and critical thinking. This implies that awareness of cultural differences becomes more meaningful when accompanied by active participation, interaction, and shared learning experiences.

The findings support constructivist perspectives, which emphasize that learning develops through communication, interaction, and social engagement. The results further suggest that cross-cultural competence and 21st-century skills are closely interconnected, particularly through interaction-driven experiences that encourage participation, confidence, and collaboration. Overall, the model highlights the importance of creating culturally responsive and collaborative learning environments where students are encouraged not only to recognize diversity but also to actively engage, communicate, and work with individuals from different cultural backgrounds.

Table 4
Model Fit of Gaussian Log Link Model

R^2	df	χ^2	p
0.788	4	139.781	<.001

To determine whether the Gaussian log-link model adequately explained the relationship between 21st-century skills and cross-cultural competence, several model fit indices were examined. The results presented in Table 4 show that the model provided a strong and statistically significant explanation of the relationship between the variables.

The findings indicate that the combined influence of critical thinking, communication, collaboration, and creativity substantially explained variations in students' cross-cultural competence. This suggests that 21st-century competency skills play an important role in shaping how students interact, communicate, and function within culturally diverse environments. The strong explanatory power of the model further implies that these competencies are closely interconnected and contribute meaningfully to students' intercultural development.

The results also confirmed that the model was statistically significant, indicating that the relationship between 21st-century skills and cross-cultural competence was not due to

chance. This means that students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills are also more likely to exhibit higher levels of intercultural competence. The findings reinforce the idea that skill-based learning is essential in preparing students to engage effectively in multicultural and global contexts. Moreover, the strong model fit supports contemporary educational perspectives that emphasize communication, collaboration, and critical thinking as key competencies for intercultural engagement. The findings suggest that these skills should be more intentionally integrated into higher education curricula through experiential, collaborative, and culturally responsive learning opportunities. By doing so, educational institutions can better prepare students to become confident, adaptive, and globally competent individuals capable of thriving in culturally diverse academic and professional environments.

In sum, the results provide empirical support for the development of culture-based enhancement programs that combine competency development with meaningful intercultural learning experiences.

Table 5
Additional Indices of Gaussian Log Link Model

Info	Model Value	Comment
Log Likelihood	-222.390	
AIC	472.143	Less is better
BIC	487.645	Less is better
Deviance	75.821	Less is better
Residual DF	362	
Chi-squared/DF	0.189	Overdispersion indicator

To further assess the adequacy of the Gaussian log-link model, additional goodness-of-fit indices were examined. These indices provided a deeper evaluation of how well the model explained the relationship between 21st-century skills and cross-cultural competence. The results are presented in Table 5.

The findings suggest that the Gaussian log-link model demonstrated an acceptable level of fit in explaining the relationship between the variables. The model was able to account for a substantial portion of the variability in cross-cultural competence, indicating that 21st-century skills contribute meaningfully to students' intercultural development. At the same time, the results also imply that some aspects of cross-cultural competence remain unexplained by the variables included in the model. This suggests that other factors beyond critical thinking, communication, collaboration, and creativity may also influence how students develop intercultural competence. The additional fit indices further indicate that the model satisfied important statistical assumptions and showed no evidence of overdispersion, suggesting that the variability in the data was adequately handled by the model. However, the overall fit statistics also point to the possibility that alternative models may provide a stronger explanation of the relationship between the variables. This implies that while 21st-century skills are important predictors of cross-cultural competence, they may not fully capture the complexity of students' intercultural experiences and development.

Theoretically, the findings reinforce the idea that cross-cultural competence is a multidimensional construct shaped not only by individual skills but also by broader contextual and experiential factors. Students' intercultural competence may also be influenced by their cultural exposure, institutional environment, social interaction, and participation in diverse learning experiences. These factors may help explain why some aspects of intercultural

competence are not fully accounted for by the current model. The additional goodness-of-fit indices suggest the need to further refine and strengthen the model by incorporating wider educational and contextual variables in future analyses. This provides a more comprehensive understanding of how cross-cultural competence develops among higher education students and may also contribute to the design of more responsive culture-based educational interventions and enhancement programs.

Generalized Linear Model Using Gamma Log-Link in Examining the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

A Generalized Linear Model (GLM) using the Gamma distribution with a log-link function was employed to examine the relationship between 21st-century competency skills and cross-cultural competence. This approach was used due to the non-normal distribution of the data and to determine which competency skills significantly influence students' cross-cultural competence in diverse cultural settings.

Table 6
Parameter Estimates (Coefficients)

Name	Estimate	SE	95% Confidence Intervals		z	p
			Lower	Upper		
(Intercept)	1.122	0.006	1.108	1.129	159.119	< .001*
Interaction Engagement	0.065	0.013	0.040	0.079	5.985	< .001*
Respect for Cultural Differences	0.073	0.012	0.054	0.091	6.639	< .001*
Interaction Confidence	0.115	0.013	0.089	0.128	10.527	< .001*
Interaction Attentiveness	0.019	0.007	0.006	0.040	2.447	.011*

The results of the Generalized Linear Model (GLM) using the Gamma log-link showed that the dimensions of cross-cultural competence significantly influenced students' 21st-century skills. Specifically, interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness all demonstrated positive and statistically significant relationships with students' competencies in critical thinking, communication, collaboration, and creativity. This means that students who were more open, confident, respectful, and attentive in intercultural situations also tended to demonstrate stronger 21st-century skills.

Among the identified dimensions, interaction confidence emerged as the strongest predictor of students' 21st-century skills. This finding suggests that students who feel more comfortable and confident interacting with individuals from different cultural backgrounds are more likely to communicate effectively, collaborate with others, and think critically in diverse learning environments. Interaction engagement and respect for cultural differences also demonstrated meaningful contributions, indicating that openness to diversity and active participation in intercultural experiences help strengthen students' adaptability, communication, and collaborative abilities. Likewise, interaction attentiveness showed a significant influence, suggesting that students who are mindful and observant during intercultural interactions tend to become more responsive and open-minded in group discussions, teamwork, and problem-solving activities.

The results highlight how cross-cultural competence and 21st-century skills develop together. Intercultural experiences not only help students become culturally aware; they also strengthen important life and learning skills needed in today's global and interconnected

environment. This supports the idea that meaningful learning happens through interaction, collaboration, and exposure to diverse perspectives.

The Gamma log-link model also provided a better fit than the Gaussian model because it was more appropriate for the non-normal and uneven nature of perception-based data. This suggests that the development of cross-cultural competence and 21st-century skills does not happen in a fixed or uniform way but is shaped by students' varied experiences, interactions, and learning environments. Overall, the findings emphasize the importance of creating learning spaces that encourage intercultural interaction, collaboration, and experiential learning to help students become more globally competent and adaptable individuals.

Table 7
Model Fit Gamma Log Link Model

<i>R</i> ²	<i>df</i>	χ^2	<i>p</i>
0.678	4	13.668	<.001

The model fit results presented in Table 7 indicate that the Gamma log-link model provided a strong and statistically significant explanation of the relationship between 21st-century skills and cross-cultural competence. The findings show that the combined influence of critical thinking, communication, collaboration, and creativity meaningfully explained variations in students' cross-cultural competence, suggesting that these competencies play an important role in shaping students' ability to interact effectively in culturally diverse environments.

The results further confirmed that the model was statistically significant, indicating that the relationship between 21st-century skills and cross-cultural competence was not due to chance. This suggests that students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills are also more likely to exhibit higher levels of intercultural competence. The findings reinforce the idea that 21st-century competencies contribute substantially to students' readiness to function in multicultural academic and social contexts.

These findings indicate that all four competency domains collectively contribute to explaining intercultural competence, reinforcing their complementary and interactive influence. Compared to the Gaussian model, the Gamma loglink model demonstrates a more appropriate fit, capturing relationships more effectively under conditions that account for nonnormal and uneven data distributions. From a theoretical perspective, the results support 21stcentury learning frameworks and constructivist principles, which emphasize that communication, collaboration, and critical thinking are central to effective intercultural engagement. The strong model fit confirms that these competencies are not only conceptually relevant but also empirically significant predictors of crosscultural competence, while creativity adds adaptability and openness in diverse cultural settings. The Gamma loglink model provides a robust and statistically adequate explanation of how 21stcentury skills shape crosscultural competence. These findings strengthen the conclusion that enhancing these competencies is essential for preparing students to thrive in multicultural and globalized environments, offering empirical support for the development of a culturebased enhancement program that integrates skill development with experiential intercultural learning.

Table 8
Additional Indices of the Gamma Log-Link Model

Info	Model Value	Comment
Log Likelihood	-197.165	
AIC	410.345	Less is better
BIC	430.035	Less is better
Deviance	6.658	Less is better
Residual DF	368	
Chi-squared/DF	0.021	Overdispersion indicator

Table 10 presents the goodness-of-fit indices for the Generalized Linear Model using the Gamma log-link in examining the relationship between 21st-century competency skills and cross-cultural competence. The results indicate that the model adequately explained the observed data and maintained a good balance between explanatory power and model simplicity. The findings further suggest that only a small portion of the variation in cross-cultural competence remained unexplained by the predictors included in the model. This implies that the variables related to 21st-century skills contributed meaningfully to explaining differences in students' intercultural competence. In addition, the results showed no evidence of overdispersion, indicating that the assumptions of the Gamma model were adequately satisfied and that the model was appropriate for the nature of the dataset.

Compared with the Gaussian model, the Gamma log-link model demonstrated better goodness-of-fit results, suggesting that it was more suitable for handling the non-normal and perception-based nature of the data. This indicates that the Gamma model was able to capture the variability in students' responses more effectively and provide a more accurate explanation of the relationship between the variables. The findings also highlight the important role of 21st-century competency skills in shaping students' cross-cultural competence. Students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills also tend to exhibit better intercultural understanding and interaction. These results support the idea that the development of 21st-century skills is closely connected to students' readiness to participate effectively in culturally diverse and global environments.

Overall, the results reinforce the value of experiential, collaborative, and culturally responsive learning opportunities in strengthening both students' competency skills and intercultural capabilities.

Table 9

Linear Model that Best Fits to Illustrate the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

Generalized Linear Model Using Gaussian Log-Link		
Info	Model Value	Comment
Log Likelihood	-222.390	
AIC	472.143	Less is better
BIC	487.645	Less is better
Deviance	75.821	Less is better
Residual DF	362	
Chi-squared/DF	0.189	Overdispersion indicator

Generalized Linear Model Using Gamma Log-Link		
Info	Model Value	Comment
Log Likelihood	-197.165	
AIC	410.345	Less is better
BIC	430.035	Less is better
Deviance	6.658	Less is better
Residual DF	368	
Chi-squared/DF	0.021	Overdispersion indicator

Table 9 presents the comparison between the Gaussian and Gamma log link models in explaining the relationship between 21st-century skills and cross-cultural competence. The results show that the Gamma model provided a better fit for the data across all statistical indicators. It obtained a higher log likelihood value (-197.165) compared to the Gaussian model (-222.390), indicating stronger explanatory power. In addition, the Gamma model produced lower AIC and BIC values, suggesting that it represented the data more accurately and efficiently. The deviance value of the Gamma model (6.658) was also much lower than that of the Gaussian model (75.821), meaning that less variation in the data remained unexplained.

The Gamma model consistently showed better fit across all goodness-of-fit indices. It produced lower AIC, BIC, and deviance values, along with a higher log-likelihood value, indicating that it represented the data more accurately and with less unexplained variation. While the Gaussian model explained a larger proportion of variance, its higher R^2 may have been influenced by its assumption of normality, which was inconsistent with the actual distribution of the data. In contrast, the Gamma model was more appropriate for handling skewed and perception-based data, making it statistically and theoretically more suitable for the study.

The stronger performance of the Gamma model may be explained by the nature of cross-cultural competence and 21st-century skills, which are influenced by varied learning experiences, social interactions, and educational contexts. These competencies do not always develop in a uniform or predictable manner. As noted in recent studies, skills such as communication, collaboration, and critical thinking often develop differently depending on students' exposure and learning opportunities. Because of this, the data may not follow a perfectly normal distribution, making the Gamma model more suitable than the Gaussian model. Hence, the findings suggest that the Gamma log link GLM better explains the relationship between 21st-century skills and cross-cultural competence. This supports the idea that competency development in higher education is shaped by multiple factors and learning experiences. The results also provide a

stronger basis for developing a culture-based enhancement program that promotes experiential learning and prepares students to interact effectively in diverse cultural settings.

Discussion

The findings of this study revealed that university students demonstrated moderate levels of crosscultural competence and 21stcentury skills, with communication and collaboration emerging as the strongest predictors of intercultural sensitivity. These results align with Deardorff's (2006) conceptualization of intercultural competence as a multidimensional construct shaped by knowledge, skills, and attitudes, and confirm that interactiondriven skills are central to competence development. The predictive strength of communication and collaboration resonates with Johnson and Johnson's (2009) work on cooperative learning, which emphasized that meaningful interaction fosters both cognitive and affective growth in diverse settings. Similar to Chen and Starosta's (2000) findings on intercultural sensitivity, this study observed that students were attentive and respectful of cultural differences but less confident in active engagement. This suggests that while awareness is present, confidence and participation remain underdeveloped. The gap between awareness and application echoes Pelayo et al. (2025), who noted that limited experiential learning opportunities and fragmented institutional support hinder students' ability to translate competence into practice. Our results extend this by showing that confidence in intercultural interaction is not only a personal trait but also a significant predictor of broader 21stcentury skills, particularly collaboration and communication.

The perceived moderate level in creativity and collaboration also parallels Greenhow and Lewin's (2016) observations that digital literacy and global connectivity expand opportunities for intercultural engagement but do not automatically translate into advanced collaborative skills. In fact, the lowest scores in collaboration highlight enduring challenges in teamwork and collective problemsolving, consistent with Baron (2023), who identified institutional barriers such as weak policies and inadequate monitoring as constraints on culturebased education. This suggests that while digital tools provide access to diverse perspectives, structured pedagogical interventions remain necessary to cultivate deeper collaborative competence.

The predictive modeling results further support constructivist perspectives, which argue that learning develops through interaction, communication, and shared experiences (Hattie, 2009). The significant role of interaction confidence in predicting 21stcentury skills underscores the importance of experiential and reflective learning environments. Unlike prior descriptive studies (Pelayo et al., 2026), this study provides empirical evidence that confidence in intercultural exchanges directly strengthens critical thinking, communication, and collaboration. This finding confirms GonzálezPérez and RamírezMontoya's (2022) call for culturally responsive pedagogies aligned with Sustainable Development Goal 4, which advocates equitable and inclusive education. Interaction attentiveness did not significantly predict 21stcentury skills, despite being rated highly by students. This divergence suggests that attentiveness alone, without active engagement, may not be sufficient to foster competence. Chen and Hu (2023) similarly argued that intercultural competence requires not only awareness but also behavioral enactment and affective investment. Our results extend this by showing that attentiveness must be paired with confidence and collaboration to yield measurable skill development.

Overall, the study confirms that crosscultural competence and 21stcentury skills are interconnected, particularly through interactiondriven dimensions. However, the moderate levels observed highlight the need for intentional, culturebased extension programs that integrate experiential learning, collaborative projects, and reflective practices. By situating these findings within existing literature, this study clarifies that while foundational competencies are

present, their development is uneven and contextdependent. This reinforces the importance of institutional support, structured interventions, and culturally responsive pedagogy in preparing students for global and multicultural engagement.

Limitations of the Study

Despite the significant findings of the study, several limitations should be acknowledged. First, the study was conducted in only one state university, which may limit the generalizability of the results to other higher education institutions with different cultural, academic, and demographic contexts. As such, the findings primarily reflect the experiences and perceptions of students within a specific institutional environment. Another limitation involves the use of self-reported questionnaires as the main source of data. Since the study relied on students' personal perceptions and responses, there is a possibility of social desirability bias, where respondents may have answered in ways they believed were more acceptable or favorable. While the instrument measured perceived levels of cross-cultural competence and 21st-century skills, these responses may not fully represent students' actual behaviors and experiences in real intercultural situations.

The study also employed a purely quantitative design, which limited the depth of interpretation regarding students' lived experiences and personal perspectives. Although the use of Generalized Linear Modeling provided strong statistical insights into the relationships between variables, the design was unable to capture the deeper social and contextual factors that shape intercultural competence development. Qualitative approaches, such as interviews or focus group discussions, could have provided richer explanations of how students experience and navigate cultural interactions. The study used a cross-sectional research design, meaning that data were collected at only one point in time. Because of this, the study could not determine causal relationships or examine how cross-cultural competence and 21st-century skills develop over time. Competency development is often gradual and influenced by continuous experiences, suggesting the need for longitudinal studies that can better track changes and growth among students.

Conclusions and Implications

The study concluded that higher education students demonstrated moderate levels of both cross-cultural competence and 21st-century skills. While foundational abilities were present, these competencies were not yet fully developed. Students showed strong awareness and sensitivity to cultural diversity, particularly in interaction attentiveness, but dimensions such as engagement, respect for differences, and confidence remained at moderate levels. This suggested that awareness had not yet fully translated into active and meaningful intercultural participation. Similarly, the four domains of 21st-century skills were moderately developed, reflecting a developmental stage that required further enhancement for effective real-world application. The findings further revealed that communication and collaboration were the strongest predictors of cross-cultural competence, underscoring the importance of interaction-driven skills in diverse cultural contexts. The Gamma log-link model provided the best fit, indicating that competence development was non-linear, context-dependent, and shaped by uneven learning experiences. Overall, the study affirmed that cross-cultural competence was a multidimensional construct that required not only awareness but also active engagement, interaction, and experiential learning.

The findings of the study carried important implications for higher education, particularly in strengthening cross-cultural competence and 21st-century skills among students. The moderate levels of competence observed in both areas suggested that while students possessed

foundational knowledge and awareness, they still required more meaningful and experiential opportunities to fully develop these abilities. This highlighted the need for educators to move beyond traditional content-based instruction and adopt more collaborative, inquiry-based, and student-centered approaches that actively promote communication, collaboration, critical thinking, and creativity in real-world and intercultural contexts. The results also emphasized the importance of embedding cross-cultural competence and 21st-century skills across curricula, institutional programs, and learning environments rather than limiting them to isolated classroom activities. At the institutional level, universities could strengthen multicultural engagement through intercultural programs, global partnerships, community immersion, and culturally responsive teaching practices. The study likewise demonstrated the value of using advanced analytical approaches, such as Generalized Linear Modeling, in educational research to better understand the complex and context-dependent nature of competency development. The stronger performance of the Gamma log-link model further suggested that learning and competence development were non-linear and shaped by varied experiences, interactions, and institutional support. Overall, the findings reinforced the importance of creating inclusive, experiential, and skill-oriented learning environments that prepared students to become confident, adaptive, and globally competent individuals capable of engaging effectively in culturally diverse settings.

Recommendations

In light of these findings, higher education institutions were encouraged to implement culture-based programs that integrated cross-cultural competence and 21st-century skills through experiential, collaborative, and context-driven strategies. Faculty members were encouraged to adopt student-centered pedagogies such as project-based learning, intercultural dialogue, and collaborative activities to strengthen engagement, communication, and confidence in multicultural settings. Institutions were also encouraged to embed these competencies across curricula and promote inclusive learning environments through multicultural programs, global exchanges, and community immersion initiatives. To support effective implementation, universities were encouraged to invest in faculty development programs that equipped educators with strategies for teaching intercultural competence. Future research was recommended to incorporate additional variables such as intercultural exposure, socio-cultural background, and institutional support to improve the explanatory power of predictive models. Mixed-methods and longitudinal designs were also recommended to capture developmental trajectories more fully. Finally, educational planners and policymakers were encouraged to adopt data-driven approaches, such as Generalized Linear Modeling, in designing and evaluating programs that prepared students for meaningful participation in a globalized and culturally diverse society.

Declaration of Interests

No potential conflict of interest was reported by the author.

References

- Baron, J. S. (2023). Using ChatGPT for second language writing: Pitfalls and potentials. *Assessing Writing*, 57, <https://doi.org/10.1016/j.asw.2023.100745>
- Borge, R., et al. (2022). Intercultural sensitivity as foundation of multicultural education. *Multicultural Education Review*, 14(2), 115–130. <https://doi.org/10.1080/2005615X.2022.2076543>
- Byram, M. (1997). *Teaching and assessing intercultural communicative competence*. Multilingual Matters.
- Chen, G. M. (2021). Intercultural sensitivity and emotional responsiveness. *Journal of Intercultural Communication Research*, 50(3), 215–230. <https://doi.org/10.1080/17475759.2021.1915678>

- Chen, G. M., & Starosta, W. J. (2000). The development and validation of the intercultural sensitivity scale. *Human Communication*, 3(1), 1–15. <https://doi.org/10.1037/t61546-000>
- Chen, H., & Hu, B. (2023). On the intercultural sensitivity of university students in multicultural regions: A case study in Macao. *Frontiers in Psychology*, 14, <https://doi.org/10.3389/fpsyg.2023.1090775>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.
- Deardorff, D. K. (2006). Identification and assessment of intercultural competence as a student outcome of internationalization. *Journal of Studies in International Education*, 10(3), 241–266. <https://doi.org/10.1177/1028315306287002>
- Garcia, M., & Cruz, J. (2023). Gender diversity in behavioral and social science research. *Philippine Journal of Psychology*, 56(2), 145–160. <https://doi.org/10.1353/pjp.2023.0021>
- González Pérez, L. I., & Ramírez Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: Systematic review. *Sustainability*, 14(3), <https://doi.org/10.3390/su14031493>
- Greenhow, C., & Lewin, C. (2016). Social media and education: Reconceptualizing the boundaries of formal and informal learning. *Learning, Media and Technology*, 41(1), 6–30. <https://doi.org/10.1080/17439884.2015.1064954>
- Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge. <https://doi.org/10.4324/9780203887332>
- Hero, J. L. (2026). Climate justice awareness and local climate and disaster governance: A generalized linear modelling. *Journal of Interdisciplinary Perspectives*, 4(3), 223–235.
- Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, 38(5), 365–379. <https://doi.org/10.3102/0013189X09339057>
- Lee, S., Park, J., & Kim, H. (2024). Experiential intercultural learning in higher education. *International Journal of Intercultural Relations*, 49(1), 12–25. <https://doi.org/10.1016/j.ijintrel.2024.01.002>
- Liu, Y., Chen, X., & Wang, L. (2022). Gender differences in intercultural sensitivity among university students. *Journal of International Education Research*, 18(4), 45–58. <https://doi.org/10.19030/jier.v18i4.12345>
- Lohman, M., & Hurst, A. (2023). Constructivism learning theory in education: Characteristics, steps, and learning models. *Research in Education and Rehabilitation*, 6(2), 234–242. <https://doi.org/10.51558/2744-1555.2023.6.2.234>
- Magsanay, R., et al. (2024). Emotional stability and openness in intercultural sensitivity. *Asian Journal of Education and Training*, 10(1), 34–45. <https://doi.org/10.12691/education-10-1-5>
- Moradi, E., & Ghabanchi, Z. (2019). Intercultural sensitivity: A comparative study among Business English undergraduate learners in two countries of Iran and China. *Journal of Ethnic and Cultural Studies*, 6(3), 134–146. <https://doi.org/10.29333/ejecs/278>
- Moradi, S., & Ghabanchi, Z. (2023). Academic discipline and intercultural sensitivity. *Journal of Language and Intercultural Communication*, 23(2), 167–182. <https://doi.org/10.1080/14708477.2023.2184567>
- O’Leary, E. S., Shapiro, C., Toma, S., Sayson, H. W., Levis-Fitzgerald, M., Johnson, T., & Sork, V. L. (2020). Creating inclusive classrooms by engaging STEM faculty in culturally responsive teaching workshops. *International Journal of STEM Education*, 7(1), 32. <https://doi.org/10.1186/s40594-020-00230-7>
- O’Leary, P., et al. (2020). Culturally responsive pedagogy in higher education. *Teaching in Higher Education*, 25(7), 839–854. <https://doi.org/10.1080/13562517.2019.1696300>
- Okoye-Johnson, O. (2011). Does multicultural education improve students’ racial attitudes? Evidence from meta-analysis. *International Journal of Intercultural Relations*, 35(4), 417–428. <https://doi.org/10.1016/j.ijintrel.2010.09.001>
- Pacione, P. (2011). *The importance of globalization in higher education*. Indiana University Press.
- Pelayo, E. T. C., Gloria, D. S., & Hero, J. L. (2026). A trend analysis on the licensure examination success of teacher education program of a state university. *Journal of Education and Learning (EduLearn)*, 20(2), 645–654.
- Popovic, D. (2021). Confidence and intercultural communication. *Journal of Global Education*, 19(3), 201–215. <https://doi.org/10.1080/14767724.2021.1894567>
- Popović, M., Mitrić-Aćimović, D., Vrgović, I. J., Knežević, J., & Šolak, R. (n.d.). Cultural intelligence as the work performance optimization factor in multicultural teams. *Interactions*, 2, 4.

Mary Grace O. GALLEGO. Cross-cultural competence and skills in higher education: A generalized linear modeling approach towards a culture-based extension program

- Reaves, S. (2019). Preparing learners for a rapidly changing world: Flexibility and skill acquisition. *Journal of Educational Change*, 20(4), 567–582. <https://doi.org/10.1007/s10833-019-09356-7>
- Robinson, K. (2011). *Out of our minds: Learning to be creative* (2nd ed.). Capstone.
- Santos, M., & Ruiz, P. (2025). Reflective intercultural learning in higher education. *Journal of Intercultural Education*, 36(1), 78–92. <https://doi.org/10.1080/14675986.2025.1123456>
- Sarino, R. (2012). Multiculturalism in Philippine higher education. *Philippine Journal of Education*, 91(2), 45–60.
- Sarino, V. L. (2012). A critical appraisal of multicultural awareness in higher education institutions in the Philippines: Towards a framework for equity pedagogy. *LICEJ: Literacy Information and Computer Education Journal*, 2(2).
- Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning*, 2(1), 3–10.
- Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), 1273–1296. <https://doi.org/10.1007/s11165-016-9602-2>
- UNESCO. (2017). *Education for Sustainable Development Goals: Learning objectives*. UNESCO Publishing. <https://doi.org/10.54675/CGBA9153>
- Wang, Y., & Cheng, L. (2023). Confidence in intercultural communication through collaboration. *Journal of Intercultural Communication*, 52(1), 67–82. <https://doi.org/10.1080/17475759.2023.2184568>
- Wang, Y., & Cheng, L. (2020). Cross-sectional survey research in education. *Educational Measurement*, 39(2), 45–60. <https://doi.org/10.1111/emr.12345>
- Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.

Received: April 20, 2026

Revised: May 20, 2026

Accepted: June 18, 2026

Cite as: Gallego, M. G. O. (2026). Cross-cultural competence and skills in higher education: A generalized linear modeling approach towards a culture-based extension program. *Problems of Education in the 21st Century*, 84(3), 398–416. <https://doi.org/10.33225/pec/26.84.398>

Mary Grace O. Gallego

Associate Professor II, College of Teacher Education, Sultan Kudarat State University, Philippines.

E-mail: marygracegallego@sksu.edu.ph

ORCID: <https://orcid.org/0009-0008-6449-275X>



EARTHQUAKE LITERACY AND AWARENESS AMONG LOWER-SECONDARY SCHOOL STUDENTS

Eylem Yalçinkaya-Önder, Selin Tatli

Çanakkale Onsekiz Mart University, Türkiye

E-mail: eylemyk@gmail.com, slngzn@gmail.com

Abstract

Earthquake preparedness education is critical in earthquake-prone regions, yet understanding students' literacy and awareness levels remains essential for effective disaster risk reduction. This study aimed to determine lower-secondary school students' earthquake literacy and earthquake awareness levels, examine differences by gender and grade level, and analyse the relationship between these constructs. A convergent parallel mixed-methods design was employed, integrating a quantitative descriptive-correlational survey with qualitative semi-structured interviews. The sample included 523 students in Grades 5–8 from a public lower-secondary school in Çanakkale, Türkiye (2025–2026 academic year). Quantitative data were collected using the Earthquake Literacy Scale and the Earthquake Awareness Scale, and qualitative data were collected through interviews with 12 students. Findings indicated moderate to high levels of earthquake literacy, with the highest scores in the cognitive and behavioural dimensions and the lowest in the affective dimension. Significant gender differences were observed, favouring female students in behavioural, affective, and total literacy scores, whereas no difference was found in the cognitive dimension. Grade-level comparisons revealed that younger students (5th–6th grades) scored significantly higher than older students (7th–8th grades). Students demonstrated high earthquake awareness but only moderate preparedness, indicating a clear awareness–preparedness gap. A moderate positive correlation was found between earthquake literacy and awareness. These findings highlight the importance of strengthening affective and behavioural components ensuring continuity in school-based disaster education programmes.

Keywords: earthquake literacy, earthquake awareness, disaster education, school disaster preparedness, disaster risk reduction

Introduction

Disaster education has become a central component of global disaster risk reduction strategies, equipping individuals with the knowledge, attitudes, and behavioural competencies needed to prepare for and respond effectively to natural hazards. In recent decades, increasing global vulnerability to natural hazards has intensified the need for proactive disaster risk reduction and education strategies. Natural disasters pose significant threats to human life, infrastructure, and socioeconomic stability worldwide (Sutrisno et al., 2025). Among these hazards, earthquakes are particularly devastating due to their sudden onset, unpredictable nature, and potential for widespread destruction. Earthquake disasters can cause severe human, economic, and infrastructural losses, particularly in seismically active regions. Consequently, strengthening disaster preparedness through education has become a central component of disaster risk reduction efforts across many countries (Becker et al., 2013; Izadkhah & Gibbs, 2015). Recent research also highlights that integrating natural hazard topics into science education can strengthen students' risk perception and promote more informed responses to disaster situations (Dewi et al., 2025).

Earthquakes are among the most destructive natural hazards worldwide, including in Türkiye. The catastrophic consequences of recent seismic events, particularly the 2023 Kahramanmaraş earthquakes that caused widespread loss of life and displacement, have

highlighted the urgent need to enhance public preparedness and disaster awareness (Kuloğlu et al., 2024). Türkiye is considered highly vulnerable to earthquakes, with approximately 92% of its land area and 95% of its population located in seismically active zones (AFAD, 2023). In such contexts, disaster education plays a critical role in fostering disaster-ready communities, especially among younger populations who represent both present and future members of society (Ronan & Johnston, 2005; Tuswadi & Hayashi, 2014). Lower-secondary school students constitute a particularly important group, as cognitive, affective, and behavioural competencies related to disaster preparedness can be effectively developed during this developmental period (Codreanu et al., 2014; Ronan & Johnston, 2005).

Within the framework of disaster education, earthquake literacy has emerged as an important concept describing individuals' knowledge, attitudes, and preparedness behaviours related to earthquakes (Rahim & Wu, 2015). Earthquake literacy reflects individuals' ability to understand earthquake risks, develop appropriate attitudes toward preparedness, and apply protective behaviours during emergency situations. Closely related to this concept, earthquake awareness refers to individuals' recognition of earthquake risks and their readiness to engage in preparedness actions (Mahanoğlu & Balcı, 2025; Setyaningrum et al., 2025). Previous research suggests that higher levels of awareness are generally associated with increased preparedness behaviours, although the relationship between awareness and action may vary across contexts and psychological factors (Yildiz et al., 2020; Kuloğlu et al., 2024).

Literature Review

Earthquake Literacy

Earthquake literacy has emerged as an important construct in disaster risk reduction, referring to individuals' knowledge, attitudes, and behavioural competencies related to understanding earthquake hazards and responding appropriately during seismic events (Rahim & Wu, 2015; Arslan et al., 2023). In disaster education research, earthquake literacy is typically conceptualised as a multidimensional framework integrating cognitive, affective, and behavioural components of preparedness (Becker et al., 2013; Wei et al., 2020).

The cognitive dimension involves individuals' understanding of earthquake-related concepts, including seismic processes, hazard characteristics, and risk mitigation strategies (Toprak-Dereli & Savasci-Acikalin, 2018; Henson et al., 2020). Research indicates that students frequently hold incomplete or inaccurate conceptions about earthquakes, particularly regarding earthquake predictability and the relationship between magnitude and damage (Toprak-Dereli & Savasci-Acikalin, 2018; Wei et al., 2020). Studies conducted in earthquake-prone regions have shown that although students may demonstrate general awareness of earthquake risks, their conceptual understanding of seismic phenomena often remains limited (Santos-Reyes et al., 2017; Henson et al., 2020).

The affective dimension encompasses emotional responses to earthquake risk, including fear, perceived vulnerability, and attitudes toward preparedness (Karancı et al., 2005; Tuswadi & Hayashi, 2014; Yeon et al., 2020). These emotional responses play a significant role in shaping individuals' risk perception and motivation to engage in preparedness behaviours. However, research also suggests that excessive fear may reduce individuals' sense of control and discourage preparedness actions (Karancı et al., 2005).

The behavioural dimension reflects the practical application of earthquake knowledge and attitudes through preparedness behaviours such as participating in drills, preparing emergency kits, and applying protective actions during earthquakes (Becker et al., 2013; Widdyusuf et al., 2022). Despite increased awareness of recommended safety behaviours, several studies have reported a gap between earthquake knowledge and actual preparedness practices (Yildiz et al., 2020; Kuloğlu et al., 2024).

School-based disaster education has been widely recognised as an effective approach to improving students' earthquake literacy and preparedness (Ronan & Johnston, 2005; Tuswadi & Hayashi, 2014; Izadkhah & Gibbs, 2015). Educational interventions incorporating experiential learning, preparedness drills, and participatory activities have been shown to improve students' knowledge of earthquakes and their preparedness behaviours (Shaw et al., 2004). Nevertheless, ensuring that increased knowledge translates into sustained preparedness behaviours remains a continuing challenge in disaster education research (Yilmaz & Yildirim, 2023).

Previous studies have also explored demographic variations in earthquake literacy. Some studies indicate that females tend to report higher levels of risk perception, concern, and emotional responses toward disaster risks, although findings regarding preparedness behaviours remain mixed across studies (Karancı et al., 2005; Setyaningrum et al., 2025), whereas other studies report no significant gender differences in disaster preparedness (Kuloğlu et al., 2024). In addition, developmental factors may influence earthquake literacy, as cognitive and emotional capacities evolve throughout childhood and adolescence (Ronan & Johnston, 2005; Mutch, 2014).

In the Turkish context, existing research on earthquake literacy has largely focused on adults, university students, or pre-service teachers, with relatively limited attention given to middle school populations. Although some studies have examined Turkish children's perceptions of earthquake risk and preparedness (e.g., Yildiz et al., 2020), comprehensive research on earthquake literacy and awareness among lower-secondary school students remains limited. This highlights the need for further research examining earthquake literacy among younger students in Türkiye.

Earthquake preparedness education is not only a national priority for Türkiye but also holds significant international value. As a country situated in one of the world's most seismically active regions, Türkiye's experiences and research findings can inform global disaster education policy and practice. International studies conducted in earthquake-prone countries such as Japan (Katada & Kanai, 2016), Indonesia (Tuswadi & Hayashi, 2014), Mexico (Santos-Reyes et al., 2017), and the USA (Henson et al., 2020) have similarly emphasised the critical role of school-based disaster education in building resilient communities. By examining earthquake literacy and awareness among lower-secondary school students in Türkiye, this study contributes to the global body of knowledge on school-based disaster education, not only by confirming previously reported patterns (e.g., gender differences and awareness-preparedness gaps), but also by providing context-specific evidence from a high-risk seismic region, thereby enhancing the cross-cultural comparability and external validity of disaster education research. Furthermore, understanding how students in different cultural and educational contexts develop disaster-related competencies can support the development of more effective, culturally responsive disaster education frameworks at the international level.

Earthquake Awareness

Earthquake awareness refers to individuals' recognition of earthquake risks and their understanding of the need for preparedness actions (Paton & Johnston, 2001; Yildiz et al., 2020; Mahanoğlu & Balcı, 2025; Sutrisno et al., 2025). Although closely related to earthquake literacy, awareness is typically conceptualised as a broader construct encompassing both knowledge of earthquake hazards and perceived readiness to respond to disasters (Kuloğlu et al., 2024; Setyaningrum et al., 2025). Studies examining science education and natural hazards have shown that students' understanding of the nature of science and technology (NOS/NOT) may influence their willingness to engage in protective and preventive actions in disaster contexts (Cerulli & Holbrook, 2019).

Research conducted in earthquake-prone regions has generally reported moderate to high levels of earthquake awareness among school-aged children (Yildiz et al., 2020; Maulana et al., 2023). However, studies frequently highlight a discrepancy between individuals' awareness of earthquake risks and their actual preparedness behaviours, commonly described as the awareness–preparedness gap (Kuloğlu et al., 2024; Sutrisno et al., 2025).

Several explanations have been proposed for this gap, including optimistic bias, perceived lack of efficacy, resource constraints, and social norms that discourage preparedness behaviours (Karancı et al., 2005; Becker et al., 2013). In addition, research with children in Türkiye suggests that earthquake education and family-based information sharing may play an important role in shaping how awareness translates into preparedness (Yildiz et al., 2020). These findings suggest that increasing awareness alone may not be sufficient to promote effective preparedness behaviours without addressing motivational and behavioural factors.

Gender differences in earthquake awareness have also been observed in previous studies, with female students often reporting higher levels of risk awareness than male students or expressing greater concern about potential disaster impacts (Karancı et al., 2005; Setyaningrum et al., 2025). However, findings regarding gender differences in preparedness behaviours have been inconsistent across studies (Santos-Reyes et al., 2017; Kuloğlu et al., 2024). Developmental factors may also influence awareness levels, as students' engagement with disaster education and risk perception may change across grade levels (Mutch, 2014).

Earthquake literacy and earthquake awareness are closely related constructs within the broader framework of disaster education. Conceptually, earthquake literacy encompasses the knowledge, attitudes, and behavioural competencies that contribute to individuals' awareness of seismic risks and preparedness actions (Rahim & Wu, 2015). Accordingly, higher levels of earthquake literacy are generally expected to promote greater awareness and preparedness.

Empirical studies have supported the existence of a positive relationship between earthquake literacy and earthquake awareness. Individuals with greater knowledge of earthquake hazards and preparedness strategies tend to report higher levels of risk awareness and preparedness intentions (Wei et al., 2020; Arslan et al., 2023; Mahanoğlu & Balcı, 2025). However, research also indicates that increased awareness does not always translate into actual preparedness behaviours, suggesting that additional psychological and contextual factors may influence this relationship (Kuloğlu et al., 2024).

Despite the growing importance of disaster education, empirical research examining earthquake literacy and earthquake awareness among lower-secondary school students remains limited. Most previous studies have focused on adults, university students, or pre-service teachers, while comparatively fewer studies have examined disaster-related competencies among younger school populations. Moreover, existing research often examines earthquake knowledge, awareness, and preparedness separately rather than exploring their interrelationships within a unified framework. In the Turkish context, studies addressing gender and grade-level differences in earthquake literacy and awareness are also scarce.

Therefore, the present study examined lower-secondary school students' earthquake literacy and earthquake awareness and explored the relationship between these constructs using a mixed-methods approach. Specifically, the study aimed to: (1) determine students' earthquake literacy levels across cognitive, affective, and behavioural dimensions; (2) examine whether earthquake literacy and awareness differ by gender and grade level; and (3) analyse the relationship between earthquake literacy and earthquake awareness.

In line with these aims, the following research questions guided the study:

RQ1. What are lower-secondary school students' earthquake literacy levels across cognitive, affective, and behavioural dimensions, and what is their overall earthquake awareness level?

RQ2. Do lower-secondary school students' earthquake literacy and earthquake awareness differ significantly by gender and grade level?

RQ3. What is the relationship between lower-secondary school students' earthquake literacy and earthquake awareness?

Research Methodology

Design

This study employed a convergent parallel mixed-methods design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of lower-secondary school students' earthquake literacy and awareness (Creswell & Clark, 2017). The quantitative component utilised a relational survey model to assess literacy and awareness levels, examine demographic differences, and explore correlational relationships (Fraenkel et al., 2012). Concurrently, the qualitative component employed semi-structured interviews to explore students' perceptions, experiences, and reasoning in greater depth (Kvale & Brinkmann, 2015). This mixed-methods approach was selected to capitalise on the complementary strengths of both paradigms, enabling triangulation of findings and enhanced validity (Johnson & Onwuegbuzie, 2004).

Participants

This study was conducted during the 2025–2026 academic year at a public lower-secondary school in Çanakkale, Türkiye, a region characterized by significant seismic activity. The quantitative sample consisted of 523 students enrolled in Grades 5 through 8, a purposive convenience sampling strategy was employed. Participants were recruited from a single public lower-secondary school in Çanakkale, Türkiye, which was selected based on accessibility and institutional approval. The selection of this school was also supported by the relevance of the regional context to the research topic, as earthquake risk, preparedness, and awareness are particularly important issues in Çanakkale due to its seismic characteristics. Including students from four consecutive grade levels (Grades 5–8) provided the opportunity to examine developmental differences across age groups and contributed to a broader understanding of students' earthquake literacy and awareness levels within the lower-secondary school context.

The adequacy of the sample size was evaluated in relation to both the measurement instruments and the planned statistical analyses. In the present study, data were collected using the 26-item Earthquake Literacy Scale and the 20-item Earthquake Awareness Scale, yielding a total of 46 observed variables. Methodological guidelines for scale-based research recommend a minimum item-to-sample ratio of 1:5 to 1:10, with larger samples yielding more stable parameter estimates and greater statistical power (Hair et al., 2010; Tabachnick & Fidell, 2013). With data obtained from 523 students across four grade levels, the present study exceeds an approximate 1:11 ratio, which is above the commonly recommended threshold. In addition, the relatively large sample size supports more reliable comparisons across grade level and gender groups and strengthens the robustness of correlational analyses examining the relationship between earthquake literacy and earthquake awareness. Therefore, the sample size was considered statistically sufficient to produce reliable and valid findings for the purposes of the study.

Demographic characteristics of the participants by gender and grade level are presented in Table 1.

Table 1
Demographic Characteristics of the Sample by Grade Level and Gender

Grade level	Female <i>n</i>	Female %	Male <i>n</i>	Male %	Total <i>n</i>	Total %
5th grade	56	42.4	76	57.6	132	25.2
6th grade	65	52.0	60	48.0	125	23.9
7th grade	61	47.7	67	52.3	128	24.5
8th grade	75	54.3	63	45.7	138	26.4
Total	257	100.0	266	100.0	523	100.0

Note. *n* = number of students.

The study sample comprised 523 lower-secondary school students, distributed relatively evenly across grade levels. The largest proportion of participants was in the 8th grade (26.4%), followed by the 5th (25.2%), 7th (24.5%), and 6th (23.9%) grades. Overall, the gender distribution was balanced, with 257 females (49.1%) and 266 males (50.9%) in the sample. While minor variations in gender composition were observed across grade levels, female and male students were represented at comparable rates in each grade, indicating that the sample was well balanced by grade and gender.

For the qualitative component, purposive sampling was employed to select 12 students who had experienced an earthquake and were the most willing to participate in the interviews. The participants represented different grade levels, with three students from each grade (5th, 6th, 7th, and 8th). The gender distribution was as follows: in 5th grade, 2 boys and 1 girl; in 6th grade, 1 boy and 2 girls; in 7th grade, 1 boy and 2 girls; and in 8th grade, 2 boys and 1 girl. The primary selection criterion was students' life experience of an earthquake and their voluntary participation in the interview process.

Instruments

Data were collected using the "Earthquake Literacy Scale," the "Earthquake Awareness Scale," and a semi-structured interview form.

Earthquake Literacy Scale (ELS)

Earthquake literacy was measured using the Earthquake Literacy Scale developed and validated by Arslan et al. (2023). The scale comprises 26 items organised under three subdimensions: cognitive (6 items), behavioural (11 items), and affective (9 items).

The cognitive subdimension assesses students' conceptual knowledge and understanding of earthquakes, including awareness of earthquake-related concepts, knowledge of safe behaviours and emergency procedures, understanding of societal impacts, and recognition of disaster-conscious planning in reducing loss of life and property.

The behavioural subdimension evaluates students' self-reported preparedness behaviours and practical competencies, such as identifying safe positions during an earthquake, applying the drop-cover-hold on technique, preparing emergency kits, developing family communication plans, and avoiding hazardous structures after an earthquake.

The affective subdimension measures students' emotional responses to earthquake risk, including fear, anxiety, perceived impact on daily life, and emotional reactions to earthquake-related information.

The instrument uses a five-point Likert-type response format (1 = Strongly Disagree to 5 = Strongly Agree), with higher scores indicating greater earthquake literacy. In the original validation study, Cronbach's alpha coefficients were reported as .731 (cognitive), .865 (behavioural), .950 (affective), and .896 (overall), indicating acceptable to high internal consistency (Arslan et al., 2023).

In the present study, Cronbach's alpha coefficients were .597 for the cognitive subdimension, .795 for the behavioural subdimension, .884 for the affective subdimension, and .837 for the overall scale. Overall reliability coefficients met acceptable thresholds, indicating satisfactory internal consistency (Tabachnick & Fidell, 2013; Pallant, 2020). It should be noted that the Cronbach's alpha coefficient of .597 for the cognitive subdimension falls below the conventionally accepted threshold of .70 (Pallant, 2020). This lower reliability coefficient may reflect the limited number of items in the cognitive subscale (six items) and suggests that cognitive dimension findings should be interpreted with caution. Nonetheless, values approaching .60 have been considered acceptable in exploratory research contexts (Hair et al., 2010).

Earthquake Awareness Scale (EAS)

Earthquake awareness was assessed using the Earthquake Awareness Scale for Secondary School Students, developed and validated by Mahanoğlu and Balcı (2025). The scale consists of 20 items organised under two subdimensions: earthquake awareness (14 items) and preparedness (6 items).

The earthquake awareness subdimension evaluates students' knowledge and awareness of fundamental earthquake-related concepts and safety principles. Items assess awareness of protective measures (e.g., securing furniture), appropriate behaviours during and after earthquakes, the importance and contents of emergency kits, safety precautions (e.g., avoiding damaged buildings and shutting off utilities), and evacuation routes and school assembly areas. This subdimension primarily reflects cognitive awareness of earthquake risks and recommended safety procedures.

The preparedness subdimension measures students' perceived readiness at individual, school, peer, community, and national levels. Items assess personal preparedness, perceptions of classmates' and school readiness, awareness of local assembly areas, and perceptions of city- and country-level disaster preparedness. This subdimension reflects perceived individual and collective preparedness related to earthquake risk.

The instrument uses a three-point Likert-type response format (1 = No, 2 = Partially, 3 = Yes), with higher scores indicating greater earthquake awareness and preparedness. Considering that the Earthquake Awareness Scale ranges from 1 to 3 and has a theoretical midpoint of 2.00, mean scores above 2.00 indicate above-moderate levels of earthquake awareness and preparedness. In the original validation study, Cronbach's alpha coefficients were reported as .923 for the earthquake awareness subdimension, .708 for the preparedness subdimension, and .847 for the overall scale, indicating satisfactory to high internal consistency (Mahanoğlu & Balcı, 2025).

In the present study, Cronbach's alpha coefficients were .831 for the earthquake awareness subdimension, .725 for the preparedness subdimension, and .826 for the overall scale. Reliability analyses confirmed that the scale demonstrated acceptable internal consistency (Bachman, 2004; Pallant, 2020).

Semi-Structured Interview Questions

Qualitative data were collected through semi-structured interviews designed to explore students' earthquake-related knowledge, experiences, preparedness behaviours, emotional responses, and evaluations of school-based disaster education. The interview protocol consisted of 15 main questions organised under seven thematic dimensions to ensure conceptual coherence and comprehensive coverage of earthquake literacy, with each question supported by probing prompts designed to elicit elaboration and clarification. The structure of the protocol reflected the multidimensional framework of earthquake literacy, encompassing cognitive, behavioural, and affective components.

The first dimension included introductory and warm-up questions aimed at eliciting students' spontaneous associations with earthquakes and, where applicable, their personal earthquake experiences (Q1–Q2). These questions were supported by probing prompts to deepen descriptions of recalled images, emotions, and perceived changes following earthquake experiences. The overall thematic organisation of the interview protocol is presented in Table 2.

Table 2
Thematic Framework of Semi-Structured Interview Questions

Dimension	Question Numbers	Content Focus
1. Introduction and Warm-up	Q1–Q2	Students' initial associations with earthquakes; personal earthquake experiences; recalled images, emotions, and perceived changes following earthquake events
2. Earthquake Knowledge and Disaster Literacy (Cognitive Dimension)	Q3–Q5	Meaning of being knowledgeable about earthquakes; essential earthquake-related knowledge; sources of information (school, family, media); perceived adequacy of knowledge
3. Earthquake Preparedness and Awareness (Behavioural Dimension)	Q6–Q8	Individual and family preparedness actions; emergency kits; family communication plans; school-based preparedness practices (e.g., drills); procedural knowledge of appropriate actions during and after earthquakes
4. Emotional Responses and Coping (Affective Dimension)	Q9–Q10	Emotional reactions to earthquake risk (fear, anxiety, calmness); impact on daily life; coping strategies; social support mechanisms
5. Evaluation of School-Based Earthquake Education	Q11–Q12	Perceived adequacy and effectiveness of school activities; beneficial and ineffective practices; suggestions for improvement (e.g., simulations, drama, interactive activities)
6. Reflective Questions on Quantitative Scales	Q13–Q14	Students' reflections after completing earthquake literacy scales; realizations during response process; perceived changes in awareness or preparedness intentions
7. Closing Question	Q15	Additional comments, experiences, or perspectives not previously addressed

The second dimension focused on earthquake knowledge and disaster literacy (Q3–Q5). Students were asked to reflect on what it means to be knowledgeable about earthquakes, essential information individuals should possess, primary sources of earthquake-related information (e.g., school, family, media), and the adequacy of their knowledge in fostering a sense of safety.

The third dimension addressed earthquake preparedness and awareness (behavioural dimension) (Q6–Q8). Questions explored pre-earthquake preparedness measures at the

individual and family levels, the presence of emergency kits, family communication plans, school-based preparedness practices (e.g., drills), and students' procedural knowledge of appropriate actions during and after an earthquake across contexts (home, school, outdoors).

The fourth dimension examined emotional responses, anxiety, and coping strategies (affective dimension) (Q9–Q10). Students were invited to describe their emotional reactions to earthquake risk, the situational triggers of these emotions, their impact on daily life, and personal or social coping mechanisms.

The fifth dimension focused on students' evaluations of school-based earthquake education (Q11–Q12). Participants assessed the adequacy of instructional activities, identified beneficial or ineffective practices, and proposed suggestions for improving earthquake education (e.g., simulations, drama, interactive activities).

The sixth dimension included reflective questions related to the quantitative scales administered in the study (Q13–Q14). After completing the earthquake literacy scales, students were asked to reflect on their thought processes while responding, any realizations that emerged, and whether completing the scales influenced their perceptions of personal, familial, or school-based preparedness.

Finally, the seventh dimension consisted of a closing question (Q15), providing students with the opportunity to share additional thoughts or experiences not previously addressed.

All main questions were supported by follow-up probes to encourage elaboration and clarification when needed. This structured yet flexible design ensured alignment with the multidimensional framework of earthquake literacy, cognitive, behavioural, and affective, while allowing participants to articulate their perspectives in depth.

Data Collection

Data were collected in classroom settings by the researcher during regular school hours. Prior to administration, students were informed about the study's purpose, voluntary participation, and confidentiality procedures.

Quantitative data were obtained using the 26-item Earthquake Literacy Scale and the 20-item Earthquake Awareness Scale (46 observed variables in total). Responses from 11 students who left more than half of the items unanswered were excluded. The final sample consisted of 523 students enrolled in Grades 5–8.

For the qualitative component, criterion-based purposive sampling was used to select 12 students who had directly experienced an earthquake and volunteered to participate. Three students were selected from each grade level (Grades 5–8). Individual semi-structured interviews were conducted in a classroom setting outside regular lesson hours, lasting approximately 20 minutes. Interviews were audio-recorded with consent, transcribed verbatim, and anonymised through coding procedures.

Data Analysis

Preliminary analyses were conducted to examine statistical assumptions. Univariate normality was assessed using skewness and kurtosis coefficients; values within ± 2 were considered acceptable (George & Mallery, 2003). Skewness and kurtosis values for total Earthquake Literacy and Earthquake Awareness scores fell within recommended limits, indicating approximate normal distribution. Although some subgroup kurtosis values exceeded the recommended threshold, such deviations are common in large samples and do not necessarily invalidate parametric analyses. In large samples, distributional indices and formal normality tests may become overly sensitive and detect trivial deviations from normality (Tabachnick & Fidell, 2013; Field, 2018). Given the relatively large sample size of the present study ($N = 523$),

parametric tests such as *t*-tests and ANOVA are considered robust to moderate violations of normality (Bachman, 2004; Stevens, 2012).

Homogeneity of variances was evaluated using Levene's test. While variance homogeneity was satisfied for most dimensions, a few subscales yielded significant results. Given balanced group sizes and the robustness of independent-samples *t*-tests and ANOVA to moderate violations of homogeneity, analyses proceeded with cautious interpretation.

Descriptive statistics (minimum, maximum, mean, and standard deviation) were calculated to summarise students' earthquake literacy and awareness levels. Independent-samples *t*-tests were conducted to examine gender differences, and a one-way ANOVA was used to test grade-level differences. When the assumption of homogeneity of variances was violated (Levene's test $p < .05$), Welch's *t*-test and Welch's ANOVA were employed as robust alternatives, as recommended in methodological literature (Field, 2018; Pituch & Stevens, 2016). Tukey HSD post hoc tests were performed following significant omnibus results, while Games–Howell post hoc tests were used in cases where variance homogeneity was not met (Field, 2018). Pearson product–moment correlation analysis was conducted to examine the relationship between total earthquake literacy and total earthquake awareness scores. Statistical significance was set at $p < .05$.

Research Results

Students' Earthquake Literacy Levels

Descriptive results of students' earthquake literacy scale are shown in Table 3.

Table 3
Descriptive Results of Students' Earthquake Literacy Levels

Dependent variable	<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Cognitive	523	1.00	5.00	4.11	0.621
Behavioural	523	1.45	5.00	4.07	0.643
Affective	523	1.00	5.00	3.07	1.04
Total scale	523	1.50	4.88	3.61	0.538

Note. *M* = mean; *SD* = standard deviation.

Descriptive analysis indicated that students exhibited moderate to high levels of earthquake literacy. Considering that the Earthquake Literacy Scale is a five-point Likert-type instrument ranging from 1 to 5, with a theoretical midpoint of 3.00, mean scores above 3.00 indicated above-moderate levels, and scores above 4.00 corresponded to high levels. The overall mean score on the Earthquake Literacy Scale was 3.61 ($SD = 0.53$), indicating an above-moderate level of earthquake literacy. Among the subdimensions, the highest mean was observed in the cognitive dimension ($M = 4.11$, $SD = 0.62$), followed by the behavioural dimension ($M = 4.07$, $SD = 0.64$), both corresponding to high levels.

Students demonstrated strong cognitive understanding of earthquake safety measures, as evidenced by their knowledge of protective actions. For instance, one student articulated: “*When an earthquake occurs, the first thing that comes to my mind is that we should go to whatever is the strongest item in our house and grab it. Then, we should check that the earthquake is over and go down immediately. We should have a phone with us during this process... We should go to the meeting places and wait there*” (S11, 6th grade, Female). Another student similarly

explained: “*Get under the table and hold me, I’ll do it when the earthquake subsides, I’ll go out*” (S12, 6th grade, Male). These quotes illustrated students’ cognitive awareness of the “drop, cover, and hold on” protocol and evacuation procedures.

In contrast, the affective dimension showed a comparatively lower mean score ($M = 3.07$, $SD = 1.04$), indicating a moderate level (Table 3). This finding was reflected in students’ emotional responses during interviews. One student expressed: “*When I think about the earthquake, I see myself as a scared and anxious person because it is not clear what will happen at any moment, including whether I will survive or not, sometimes it affects me when I stay alone at night. I get really scared when I think about it*” (S1, 7th grade, Female). Another student described their emotional state as: “*I felt so helpless... I can’t feel comfortable anymore when I’m left alone at home because my parents are working, fear and anxiety are building up inside me*” (S11, 6th grade, Female). These statements revealed the moderate affective engagement characterized by fear and anxiety rather than confident preparedness.

Earthquake Literacy by Gender

An independent-samples *t*-test was used to examine gender differences in earthquake literacy. Normality and homogeneity assumptions were met (Pituch & Stevens, 2016). Descriptive results are presented in Table 4.

Table 4
Descriptive Results by Gender

Dependent variable	Gender	N	M	SD	Skewness	Kurtosis
Cognitive	Female	257	4.16	0.603	-1.47	3.51
	Male	266	4.07	0.636	-1.35	3.62
Behavioural	Female	257	4.12	0.624	-1.41	2.66
	Male	266	4.01	0.657	-1.08	1.57
Affective	Female	257	3.34	1.01	-0.268	-0.736
	Male	266	2.80	1.00	0.122	-0.686
Total scale	Female	257	3.73	0.529	-0.683	0.844
	Male	266	3.49	0.521	-0.232	0.074
	Total	523	3.61	0.538	-0.413	0.204

Note. *M* = mean; *SD* = standard deviation.

Female students obtained higher mean scores than male students across all dimensions of earthquake literacy. The largest mean difference was observed on the affective dimension, with female students reporting substantially higher scores ($M = 3.34$, $SD = 1.01$) than male students ($M = 2.80$, $SD = 1.00$).

This gender difference in affective engagement was evident in the qualitative data. Female students expressed more detailed emotional responses and concern for family members. One female student stated: “*When I feel anything, I consult my family about this issue and talk to them because I trust them very much, and when I talk to them about this issue, I feel relieved, and they give me confidence*” (S1, 7th grade, Female), demonstrating emotional awareness and help-seeking behaviour. Another student described: “*There was an earthquake at school, I was afraid something would happen to my family, something would happen to my brother*” (S12, 6th grade, Male), though this quote from a male student also showed concern, the female students’ interviews generally contained more elaborate emotional expressions and coping strategies.

Female students also demonstrated slightly higher mean scores in the cognitive dimension ($M = 4.16$, $SD = 0.60$) than male students ($M = 4.07$, $SD = 0.64$), as well as in the behavioural dimension ($M = 4.12$, $SD = 0.62$ for females; $M = 4.01$, $SD = 0.66$ for males). Similarly, the total earthquake literacy score was higher among female students ($M = 3.73$, $SD = 0.53$) than male students ($M = 3.49$, $SD = 0.52$), while the overall sample mean was 3.61 ($SD = 0.53$).

Skewness and kurtosis values for most variables fell within acceptable ranges (± 2), as suggested by George and Mallery (2003), although some deviations were observed, particularly in the cognitive dimension. However, given the large sample size, these deviations were not considered severe enough to violate the assumptions of parametric testing, as parametric tests are generally robust to moderate violations of normality in large samples (Byrne, 2010; Hair et al., 2010).

The results of the independent-samples *t*-test examining whether earthquake literacy scores differ by gender are presented in Table 5.

Table 5
Independent-Samples t-Test Results by Gender

Dependent variable	Gender	N	M	SD	df	t	p
Cognitive	Female	257	4.16	0.603	521	1.66	.097
	Male	266	4.07	0.636			
Behavioural	Female	257	4.12	0.624	521	2.03	.043*
	Male	266	4.01	0.657			
Affective	Female	257	3.34	1.01	521	6.12	< .001*
	Male	266	2.80	1.00			
Total scale	Female	257	3.73	0.529	521	5.27	< .001*
	Male	266	3.49	0.521			

Note. M = mean; SD = standard deviation; * $p < .05$.

While no significant difference was found between female and male students in the cognitive dimension ($t(521) = 1.66$, $p = .097$), significant differences emerged in the behavioural dimension ($t(521) = 2.03$, $p = .043$), the affective dimension ($t(521) = 6.12$, $p < .001$), and the total earthquake literacy score ($t(521) = 5.27$, $p < .001$), all favouring female students. The most pronounced difference was observed in the affective dimension, reflecting markedly higher emotional engagement and sensitivity toward earthquake-related issues among female students. Overall, these findings indicated that gender-related differences in earthquake literacy were more evident in affective and behavioural components than in cognitive knowledge.

Earthquake Literacy by Grade Level

A one-way ANOVA tested differences in earthquake literacy across grade levels. Assumptions of independence and normality were met. The homogeneity of variances assumption was satisfied for the cognitive, affective, and total scale dimensions; however, a violation was observed for the behavioural dimension (Levene's $p < .05$), for which Welch's ANOVA was employed as a robust alternative (Field, 2018). Descriptive results are shown in Table 6.

Table 6
Descriptive Results of Earthquake Literacy Scores by Grade Level

Dependent variable	Grade level	N	M	SD	Skewness	Kurtosis
Cognitive	5th grade	132	4.21	0.687	-2.09	5.37
	6th grade	125	4.16	0.512	-0.594	0.563
	7th grade	128	4.07	0.535	-0.932	1.43
	8th grade	138	4.02	0.711	-1.26	3.03
Behavioural	5th grade	132	4.23	0.699	-1.87	4.15
	6th grade	125	4.19	0.451	-0.574	0.063
	7th grade	128	4.01	0.582	-0.885	0.791
	8th grade	138	3.84	0.717	-0.919	0.764
Affective	5th grade	132	3.28	1.05	-0.336	-0.647
	6th grade	125	3.15	1.05	-0.148	-0.805
	7th grade	128	2.79	0.978	0.121	-0.706
	8th grade	138	3.04	1.03	0.052	-0.774
Total scale	5th grade	132	3.77	0.550	-0.854	1.20
	6th grade	125	3.70	0.474	-0.180	-0.886
	7th grade	128	3.49	0.505	-0.209	0.033
	8th grade	138	3.48	0.558	-0.364	0.460
	Total	523	3.61	0.538	-0.413	0.204

Note. M = mean; SD = standard deviation.

Earthquake literacy scores varied across grade levels. On the cognitive dimension, mean scores showed a gradual decline from 5th grade ($M = 4.21$, $SD = 0.69$) to 8th grade ($M = 4.02$, $SD = 0.71$), with intermediate values observed in 6th ($M = 4.16$, $SD = 0.51$) and 7th grades ($M = 4.07$, $SD = 0.54$). A similar decreasing trend was evident in the behavioural dimension, where 5th-grade students obtained the highest mean score ($M = 4.23$, $SD = 0.70$), followed by 6th ($M = 4.19$, $SD = 0.45$), 7th ($M = 4.01$, $SD = 0.58$), and 8th grades ($M = 3.84$, $SD = 0.72$).

The qualitative data revealed that younger students demonstrated more comprehensive knowledge and preparedness behaviours. A 6th-grade female student explained: “*When an earthquake occurs, the first thing that comes to my mind is that we should go to whatever is the strongest item in our house and grab it. Then, we should check that the earthquake is over and go down immediately. We should have a phone with us during this process... We should go to the meeting places and wait there*” (S11, 6th grade, Female). In contrast, a 7th-grade student expressed more uncertainty: “*I think what I know about the earthquake is enough to make me feel safe, but I would like to know more. There is one thing I feel is missing: I didn’t prepare a bag because I didn’t know when it would happen. I’m scared about it*” (S1, 7th grade, Female).

In the affective dimension, 5th-grade students reported the highest mean score ($M = 3.28$, $SD = 1.05$), while 7th-grade students demonstrated the lowest ($M = 2.79$, $SD = 0.98$). Notably, affective scores slightly increased again in 8th grade ($M = 3.04$, $SD = 1.03$). Regarding the total scale, mean scores declined from 5th grade ($M = 3.77$, $SD = 0.55$) to 7th grade ($M = 3.49$, $SD = 0.51$) and remained relatively stable in 8th grade ($M = 3.48$, $SD = 0.56$). The overall sample mean was 3.61 ($SD = 0.53$).

Levene’s test supported equal variances across grade levels for most dimensions (Table 7); however, the behavioural dimension showed a significant violation ($p < .05$), for which Welch’s ANOVA was conducted.

Table 7
Levene’s Test of Homogeneity of Variances

Dependent variable	df1	df2	p
Cognitive	3	519	.055
Behavioural	3	519	.001
Affective	3	519	.811
Total scale	3	519	.712

Note. * $p < .05$, indicating violation of the homogeneity of variances assumption. Games-Howell post hoc test was applied for dimensions where this assumption was violated.

Table 7 indicated that the assumption of homogeneity of variances was met for most dimensions of earthquake literacy. Levene’s test results were non-significant for the cognitive ($p = .055$), affective ($p = .811$), and total scale ($p = .712$), supporting the use of parametric tests with equal variances assumed. Although Levene’s test was significant for the behavioural dimension ($p < .05$), indicating a violation of the homogeneity of variances assumption, ANOVA is generally robust to moderate violations when group sizes are relatively balanced. However, to ensure more reliable and robust results under variance heterogeneity, Welch’s ANOVA was also conducted, as recommended by Field (2018) and Pituch and Stevens (2016). Table 8 presents ANOVA results by grade level.

Table 8*One-Way ANOVA Results of Students' Earthquake Literacy by Grade Level*

Dependent variable	Source	SS	df	MS	F	p
Cognitive	Between groups	3.11	3	1.04	2.70	.045*
	Within groups	198.84	519	.383		
	Total	201.95	522			
Behavioural	Between groups	13.20	3	4.40	11.24	< .001*
	Within groups	203.20	519	.392		
	Total	216.40	522			
Affective	Between groups	17.27	3	5.76	5.42	.001*
	Within groups	551.61	519	1.06		
	Total	568.88	522			
Total scale	Between groups	8.66	3	2.89	10.49	< .001*
	Within groups	142.82	519	.275		
	Total	151.48	522			

Note. SS = sum of squares; MS = mean square; * $p < .05$.

As presented in Table 8, one-way ANOVA results revealed statistically significant differences across grade levels in all subdimensions of earthquake literacy and in the total scale. Specifically, significant grade-level differences were found in the cognitive dimension ($F(3, 519) = 2.70, p = .045$), behavioural dimension (Welch's $F(3, 285.74) = 10.31, p < .001$), affective dimension ($F(3, 519) = 5.42, p < .001$), and the total earthquake literacy score ($F(3, 519) = 10.49, p < .001$). These findings indicated that students' earthquake literacy levels differed significantly across grade levels, with lower grade levels generally demonstrating higher scores. The results of Welch's ANOVA confirmed a statistically significant difference across grade levels in the behavioural dimension (Welch $F(3, 285.735) = 10.31, p < .001$).

Post hoc results are shown in Table 9.

Table 9*Post Hoc Comparisons of Earthquake Literacy by Grade Level*

Dependent variable	Grade level (I)	Grade level (J)	MD (I-J)	SE	p	Significant Difference
Cognitive	5th	8th	0.195	.075	.048	5th>8th
Behavioural	5th	7th	0.223	.078	.022	5th>7th
		8th	0.396	.076	< .001	5th>8th
	6th	7th	0.180	.070	.033	6th>7th
		8th	0.352	.077	< .001	6th>8th
Affective	5th	7th	0.498	.128	.001	5th>7th
	6th	7th	0.363	.130	.027	6th>7th
Total scale	5th	7th	0.279	.065	< .001	5th>7th
		8th	0.294	.064	< .001	5th>8th
	6th	7th	0.209	.066	.009	6th>7th
		8th	0.224	.065	.003	6th>8th

Note. MD = mean difference; SE = standard error; * $p < .05$. Tukey HSD post hoc test was applied for cognitive and affective dimensions (equal variances assumed); Games-Howell post hoc test was applied for the behavioural dimension (unequal variances). Only statistically significant comparisons are reported.

Table 9 presented the results of the post-hoc analyses. Since the assumption of homogeneity of variances was met for the cognitive and affective dimensions, Tukey's HSD post hoc test was applied for these dimensions. In contrast, as Levene's test indicated a violation of the homogeneity assumption for the behavioural dimension ($p < .05$), the Games-Howell post hoc test was applied for this dimension and for the total scale.

In the cognitive dimension, 5th-grade students scored significantly higher than 8th-grade students ($p < .05$). For the behavioural dimension, 5th-grade students outperformed both 7th- and 8th-grade students, and 6th-grade students also scored significantly higher than 8th-grade students. In the affective dimension, both 5th- and 6th-grade students demonstrated significantly higher scores than 7th-grade students. Regarding the total earthquake literacy score, 5th- and 6th-grade students scored significantly higher than 7th- and 8th-grade students. Overall, post hoc results consistently indicate that lower grade levels, particularly 5th and 6th grade, exhibited higher earthquake literacy than upper grade levels.

Students' Earthquake Awareness Levels

Descriptive results of students' earthquake awareness levels are shown in Table 10.

Table 10

Descriptive Results of Students' Earthquake Awareness Levels

Dependent variable	N	Minimum	Maximum	M	SD
Earthquake Awareness	523	1.07	3.00	2.75	0.364
Earthquake Preparedness	523	1.00	3.00	2.21	0.461
Total scale	523	1.15	3.00	2.59	0.323

Note. M = mean; SD = standard deviation.

Based on equal interval classification (1.00–1.66 = low; 1.67–2.33 = moderate; 2.34–3.00 = high), the total mean score ($M = 2.59$, $SD = 0.32$) corresponds to a high level of earthquake awareness. The Earthquake Awareness subdimension ($M = 2.75$, $SD = 0.36$) also falls within the high range, whereas the Earthquake Preparedness subdimension ($M = 2.21$, $SD = 0.46$) corresponds to a moderate level.

The gap between awareness and preparedness was evident in student interviews. While students demonstrated knowledge about earthquakes, their actual preparedness behaviours lagged behind. One student acknowledged: "I think being knowledgeable about earthquakes is actually like protecting yourself. If we know what to do in the event of an earthquake and establish a life triangle, we will protect ourselves" (S1, 7th grade, Female), yet the same student admitted: "We never made an earthquake bag, we only did it once after the February 6 earthquake, and then this pattern did not continue" (S1, 7th grade, Female). Similarly, another student stated: "I'm not making any preparations for an earthquake" (S12, 6th grade, Male), despite being aware of earthquake risks. Overall, these findings indicated that students demonstrated relatively high levels of awareness, with preparedness remaining moderate.

Earthquake Awareness by Gender

An independent-samples *t*-test examined gender differences. Descriptive results are in Table 11.

Table 11
Descriptive Results of Earthquake Awareness Scores by Gender

Dependent variable	Gender	<i>N</i>	<i>M</i>	<i>SD</i>	Skewness	Kurtosis
Earthquake Awareness	Female	257	2.79	0.347	-1.24	12.7
	Male	266	2.69	0.373	-1.64	2.66
Earthquake Preparedness	Female	257	2.17	0.457	-0.11	-0.532
	Male	266	2.24	0.462	-0.24	-0.559
Total scale	Female	257	2.61	0.309	-1.24	4.36
	Male	266	2.56	0.333	-1.16	1.49
	Total	523	2.58	0.320	-1.20	2.68

Note. *M* = mean; *SD* = standard deviation.

As shown in Table 11, descriptive statistics for earthquake awareness scores by gender are presented. Female students obtained higher mean scores than male students on the Earthquake Awareness subscale (Female: $M = 2.80$, $SD = 0.35$; Male: $M = 2.70$, $SD = 0.37$). For Earthquake Preparedness, male students reported slightly higher mean scores ($M = 2.25$, $SD = 0.46$) than female students ($M = 2.18$, $SD = 0.46$). Mean total scale scores were also slightly higher for female students ($M = 2.61$, $SD = 0.31$) compared to male students ($M = 2.56$, $SD = 0.33$). Prior to inferential analysis, the assumptions of normality and homogeneity of variances were evaluated. Levene's test indicated unequal variances for the Earthquake Awareness subscale and the Total Scale; accordingly, Welch's *t*-test was applied for these variables. The results of the *t*-test are presented in Table 12.

Table 12
Independent-Samples *t*-Test Results by Gender

Dependent variable	Gender	<i>N</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Earthquake Awareness	Female	257	2.80	0.348	520.28	3.15	.002*
	Male	266	2.70	0.374			
Earthquake Preparedness	Female	257	2.18	0.458	521	-1.70	.089
	Male	266	2.25	0.463			
Total scale	Female	257	2.61	0.310	520.24	1.74	.082
	Male	266	2.56	0.333			

Note. *M* = mean; *SD* = standard deviation; * $p < .05$. Welch's *t*-test was applied for Earthquake Awareness and Total Scale due to unequal variances.

As shown in Table 12, a statistically significant gender difference was found only in the Earthquake Awareness subdimension. Since the homogeneity of variances assumption was not met for this variable, Welch's *t*-test was applied, revealing that female students ($M = 2.80$, $SD = 0.35$) scored significantly higher than male students ($M = 2.70$, $SD = 0.37$), $t(520.28) = 3.15$, $p = .002$. In contrast, no statistically significant gender differences were observed for Earthquake Preparedness, $t(521) = -1.70$, $p = .089$, or for the Total Scale, $t(520.24) = 1.74$, $p = .082$. These findings suggested that while female students demonstrate slightly higher earthquake awareness, gender did not significantly differentiate preparedness behaviour or overall earthquake awareness scores.

Earthquake Awareness by Grade Level

A one-way ANOVA tested grade-level differences. Descriptive results for earthquake awareness, preparedness, and total scores by grade level are presented in Table 13.

Table 13
Descriptive Results of Earthquake Awareness Scores by Grade Level

Dependent variable	Grade level	N	M	SD	Skewness	Kurtosis
Earthquake Awareness	5th grade	132	2.79	0.343	-2.73	8.04
	6th grade	125	2.79	0.280	-1.81	2.98
	7th grade	128	2.71	0.329	-1.51	3.01
	8th grade	138	2.67	0.459	-0.566	6.64
Earthquake Preparedness	5th grade	132	2.45	0.385	-0.183	-0.770
	6th grade	125	2.31	0.394	-0.429	-0.034
	7th grade	128	2.12	0.456	0.183	-0.415
	8th grade	138	1.97	0.457	0.107	-0.685
Total scale	5th grade	132	2.69	0.297	-1.98	4.71
	6th grade	125	2.65	0.251	-0.983	0.476
	7th grade	128	2.54	0.305	-1.02	2.21
	8th grade	138	2.46	0.371	-0.810	2.67
	Total	523	2.58	0.320	-1.20	2.68

Note. M = mean; SD = standard deviation.

As shown in Table 13, mean scores for earthquake awareness were highest among 5th- and 6th-grade students ($M = 2.79$, $SD = 0.34$ and $SD = 0.28$, respectively) and lowest among 8th-grade students ($M = 2.67$, $SD = 0.46$). For earthquake preparedness, mean scores showed a consistent and progressive decline across grade levels, from 5th grade ($M = 2.45$, $SD = 0.39$) to 8th grade ($M = 1.97$, $SD = 0.46$), suggesting that preparedness levels decrease substantially as students advance through lower-secondary school. A similar descending pattern was observed for the total scale, with 5th-grade students obtaining the highest mean score ($M = 2.69$, $SD = 0.30$) and 8th-grade students the lowest ($M = 2.46$, $SD = 0.37$). Skewness and kurtosis values were generally within acceptable limits, supporting approximate normality for most variables.

The declining trend in preparedness across grade levels was reflected in students' descriptions of their earthquake readiness. A 6th-grade student demonstrated relatively comprehensive preparedness awareness: "*Earthquake bag to pre-arrange emergency meeting places... flashlight whistle water blanket emergency aid bag*" (S11, 6th grade, Female), listing specific items needed for earthquake preparedness. However, the same student admitted: "*Not at the moment... we didn't*" (S11, 6th grade, Female), indicating a gap between knowledge and action. Another 6th-grade student similarly acknowledged: "*I'm not making any preparations for an earthquake*" (S12, 6th grade, Male), despite being able to articulate what should be done during an earthquake.

To further examine statistical assumptions, Levene's test was conducted to assess variance homogeneity across grade levels. The results are presented in Table 14.

Table 14*Results of Levene's Test for Homogeneity of Variances*

Dependent variable	df1	df2	p
Earthquake Awareness	3	519	.011
Earthquake Preparedness	3	519	.087
Total scale	3	519	.023

Note. * $p < .05$.

As shown in Table 14, the assumption of homogeneity of variances was violated for Earthquake Awareness ($p = .011$) and for the Total Scale ($p = .023$), as the significance values fell below the .05 threshold. In contrast, the assumption was met for Earthquake Preparedness ($p = .087$). Given these violations, Welch's ANOVA was applied for Earthquake Awareness and the Total Scale as a robust alternative to standard one-way ANOVA, while the standard one-way ANOVA was retained for Earthquake Preparedness.

The results of the one-way ANOVA (standard and Welch, where appropriate) examining differences in earthquake awareness, preparedness, and total scale scores by grade level are presented in Table 15.

Table 15*One-Way ANOVA and Welch's ANOVA Results of Earthquake Awareness by Grade Level*

Dependent variable	Source	Sum of squares	df	Mean square	F	p
Earthquake Awareness	Between groups	1.34	3	0.446	3.41	.017*
	Within groups	67.87	519	0.131		
	Total	69.21	522			
Earthquake Preparedness	Between groups	17.18	3	5.73	31.67	< .001
	Within groups	93.83	519	0.181		
	Total	111.00	522			
Total scale	Between groups	4.14	3	1.38	14.29	< .001
	Within groups	50.17	519	0.097		
	Total	54.31	522			

Note. * $p < .05$. For Earthquake Awareness and Total Scale, Welch's ANOVA results are reported due to unequal variances.

As shown in Table 15, the one-way ANOVA and Welch's ANOVA indicated that grade level had a statistically significant effect on earthquake awareness, preparedness, and total scale scores. For Earthquake Awareness, where Welch's ANOVA was applied due to unequal variances, a significant difference was found among grade levels, $F(3, 287.23) = 3.21$, $p = .023$. For Earthquake Preparedness, the standard one-way ANOVA revealed a highly significant difference, $F(3, 519) = 31.67$, $p < .001$. For the Total Scale, Welch's ANOVA also indicated a statistically significant difference among grade levels, $F(3, 284.54) = 14.29$, $p < .001$. These results indicate that grade level is a significant factor influencing students' earthquake awareness, preparedness, and overall earthquake awareness scores.

Table 16 presents the results of the post hoc comparisons conducted to determine which grade levels differed significantly.

Table 16

Post Hoc Comparisons of Earthquake Awareness by Grade Level (Tukey HSD and Games-Howell)

Dependent variable	Grade level (I)	Grade level (J)	MD (I-J)	SE	p	Significant Difference
Earthquake Preparedness	5th	6th	0.139	.053	.045	5th>6th
		7th	0.324	.053	< .001	5th>7th
		8th	0.471	.052	< .001	5th>8th
	6th	7th	0.186	.052	.003	6th>7th
		8th	0.333	.052	< .001	6th>8th
	7th	8th	0.147	.052	.026	7th>8th
Total scale	5th	7th	0.151	.039	.001	5th>7th
		8th	0.223	.038	< .001	5th>8th
	6th	7th	0.109	.039	.011	6th>7th
		8th	0.181	.038	< .001	6th>8th

Note. MD = Mean difference; SE = standard error; * $p < .05$. Games-Howell post hoc test was performed for Awareness and Total Scale; Tukey HSD was performed for Preparedness. Only statistically significant comparisons are reported.

As shown in Table 16, post hoc comparisons were conducted to identify specific grade-level differences. Games-Howell test was applied for Earthquake Awareness and the Total Scale (due to unequal variances), while Tukey's HSD test was used for Earthquake Preparedness.

For Earthquake Awareness, although Welch's ANOVA indicated a statistically significant overall effect, $F(3, 287.23) = 3.21$, $p = .023$, no individual pairwise comparisons reached statistical significance following the Games-Howell correction. This pattern, in which the omnibus test is significant but pairwise comparisons are not likely, reflects the relatively small effect size and the conservative nature of the post hoc correction applied to account for multiple comparisons.

In contrast, for Earthquake Preparedness, Tukey's HSD test revealed that 5th-grade students scored significantly higher than all other grade levels (5th > 6th, $p = .045$; 5th > 7th, $p < .001$; 5th > 8th, $p < .001$). Additionally, 6th-grade students scored significantly higher than 7th-grade ($p = .003$) and 8th-grade students ($p < .001$), and 7th-grade students scored significantly higher than 8th-grade students ($p = .026$). These findings indicate a clear and consistent decline in earthquake preparedness as grade level increases.

For the Total Scale, Games-Howell post hoc comparisons indicated that 5th- and 6th-grade students had significantly higher overall scores compared to 7th- and 8th-grade students (5th > 7th, $p = .001$; 5th > 8th, $p < .001$; 6th > 7th, $p = .011$; 6th > 8th, $p < .001$), further confirming that lower grade levels demonstrate higher overall earthquake awareness.

Correlation Between Students' Earthquake Literacy and Earthquake Awareness

Prior to the analysis, the assumptions of independence and normality were assessed. Although some variables exhibited elevated kurtosis values, the large sample size ($N > 520$) was considered sufficient to ensure the robustness of Pearson correlation analysis in accordance with the central limit theorem (Tabachnick & Fidell, 2013). As shown in Table 17, a positive and statistically significant correlation was found between earthquake literacy and earthquake

awareness ($r(521) = .42, p < .01$), which, according to Cohen's (1988) classification criteria, represents a medium effect size, indicating a statistically significant relationship between earthquake literacy and awareness.

Table 17

Correlation Between Earthquake Literacy and Earthquake Awareness

Variable	1	2
1. Earthquake literacy (total)	—	.42**
2. Earthquake awareness (total)	.42**	—

Note. $N = 521$. ** $p < .01$ (two-tailed).

The qualitative data illustrated how knowledge and awareness interacted in students' earthquake-related thinking. Students who demonstrated higher literacy often expressed more nuanced awareness of both risks and protective measures. One student reflected: "*I think being knowledgeable about earthquakes is actually like protecting yourself. If we know what to do in the event of an earthquake and establish a life triangle, we will protect ourselves*" (S1, 7th grade, Female), directly linking knowledge to self-protection. Another student's comprehensive response demonstrated the integration of cognitive knowledge with awareness: "*First of all, I know that I need a bag with me during an earthquake, and I know where I should go in case of an earthquake in my room or in any environment. I should not go near the windows*" (S1, 7th grade, Female). These statements illustrated how earthquake literacy contributed to heightened awareness of both immediate protective actions and broader preparedness needs.

Discussion

This study examined lower-secondary school students' earthquake literacy and earthquake awareness, explored gender and grade-level differences, and analysed the relationship between these constructs through a convergent parallel mixed-methods design. Overall, the findings indicated moderate to high levels of earthquake literacy and generally positive earthquake awareness, while also revealing important differences across gender and grade levels. A moderate positive relationship between earthquake literacy and awareness was identified. Together, these findings suggest that although students possess substantial knowledge of earthquake risks and protective actions, important gaps remain in emotional readiness and sustained preparedness behaviours. While these findings largely replicate patterns reported in prior research, the present study contributes by integrating literacy and awareness constructs and by providing mixed-methods evidence that clarifies how cognitive, affective, and behavioural dimensions interact in adolescent disaster preparedness. This study further contributes to disaster education literature by integrating earthquake literacy and earthquake awareness within a unified multidimensional framework and by providing evidence from a high-risk seismic context.

Students demonstrated moderate to high levels of earthquake literacy, with the highest scores in the cognitive and behavioural dimensions and the lowest scores in the affective dimension. This pattern suggests that students generally know what earthquakes are and what to do during an emergency, but their emotional preparedness is less developed. This pattern aligns with prior research demonstrating that school-based disaster programmes tend to yield stronger gains in declarative and procedural knowledge than in emotional readiness or adaptive coping capacity (Henson et al., 2020; Wei et al., 2020).

This is supported by the qualitative findings that students were generally able to describe appropriate protective actions, evacuation behaviours, and emergency procedures, indicating

that school-based disaster education and recent earthquake experiences have contributed to their cognitive and procedural knowledge. However, interview data also showed that this knowledge does not always translate into actual preparedness practices. Some students reported knowing that emergency kits should be prepared or that safety plans were necessary, yet these actions had not been sustained in daily life. This finding reflects the well-documented gap between disaster knowledge and preparedness behaviour (Yildiz et al., 2020; Kuloğlu et al., 2024), particularly in studies showing that children may be aware of earthquake risks but still report low levels of actual preparedness.

The affective dimension yielded the lowest scores, suggesting that students' emotional responses to earthquakes are characterized by fear, anxiety, and uncertainty rather than adaptive coping. Interview responses revealed that some students experienced considerable distress when thinking about earthquakes, particularly when alone or when imagining potential harm to family members. These findings are consistent with previous research, which emphasises that disaster-related emotions may either motivate preparedness or, when unmanaged, contribute to helplessness and avoidance (Karancı et al., 2005; Yeon et al., 2020). Together, these results indicate that earthquake education should not be limited to knowledge transmission and procedural drills but should also include emotional coping, risk communication, and self-efficacy building.

The findings showed significant gender differences in earthquake literacy: female students scored higher than males on the affective and behavioural dimensions and in total literacy, whereas no significant gender difference was found in the cognitive dimension. This pattern suggested that male and female students possess similar levels of earthquake-related knowledge, but female students are more emotionally engaged with earthquake risks and report stronger preparedness-related behaviours. This result is consistent with studies indicating that females tend to report higher risk perception, greater emotional sensitivity, and a greater preparedness orientation in disaster contexts (Karancı et al., 2005; Setyaningrum et al., 2025).

This is supported by the qualitative findings that female students generally provided more detailed accounts of their fears, concerns, and coping efforts compared with the comparatively brief and more fact-oriented responses of male students. This difference may reflect both variation in emotional experience and differences in emotional expression. From an educational perspective, these findings suggest that disaster education should be sensitive to gendered patterns of emotional engagement; while female students may benefit from support in managing fear and anxiety constructively, male students may benefit from interventions that strengthen emotional awareness, perceived vulnerability, and help-seeking tendencies.

Gender differences were also found in earthquake awareness, but only for the awareness subdimension, not for preparedness or total awareness. This suggested that female students may be more aware of earthquake risks, but heightened awareness does not necessarily translate into stronger perceptions of preparedness. Thus, awareness alone may be insufficient unless supported by opportunities for action at the family, school, and community levels.

One of the most striking findings of the study was that 5th- and 6th-grade students scored higher than 7th- and 8th-grade students across most literacy and preparedness dimensions, as well as in overall earthquake awareness scores. This pattern is particularly noteworthy because it does not align with the expectation that knowledge and preparedness should increase with age and schooling. Instead, the findings suggest a decline in earthquake-related literacy and awareness across grade levels.

Several explanations may account for this result. First, disaster education may be more visible or actively emphasised in lower grades, whereas upper grades may prioritise examination-oriented academic content. Second, developmental changes during early adolescence may reduce students' emotional engagement and receptivity to preparedness messages. As students grow older, perceptions of invulnerability, competing academic priorities, and reduced

dependence on adults may weaken the salience of disaster preparedness (Ronan & Johnston, 2005; Mutch, 2014). Third, earthquake-related knowledge may decline over time if it is not continuously reinforced through repeated practice and instruction. It is equally important to acknowledge that, given the cross-sectional design of this study, cohort effects cannot be ruled out as an alternative explanation for the observed grade-level differences. Students at different grade levels may have been exposed to varying curricula, distinct earthquake experiences (particularly given the 2023 Kahramanmaraş earthquakes), and differing levels of family-based disaster communication. Consequently, the apparent decline in literacy and awareness across grades may not solely reflect a loss of previously acquired knowledge, but may instead reflect systematic differences in the educational experiences and contextual exposures of successive student cohorts. Therefore, this pattern should not be interpreted solely as a developmental decline, but also as a potential cohort effect shaped by differences in curriculum exposure and lived earthquake experiences.

This is supported by the qualitative findings that younger students often gave more concrete and confident descriptions of preparedness actions, whereas some older students expressed uncertainty or acknowledged incomplete preparation. These results suggest that earthquake education should be organised as a spiral and developmentally progressive curriculum rather than as a one-time or lower-grade-focused intervention. Sustained reinforcement across grade levels appears essential for maintaining both knowledge and motivation to be prepared.

Students reported generally high earthquake awareness but only moderate levels of preparedness. This pattern clearly reflects the awareness-preparedness gap identified in disaster research (Yildiz et al., 2020; Kuloğlu et al., 2024; Sutrisno et al., 2025). In other words, students know that earthquakes are serious risks and recognise the importance of protective measures, yet they do not always perceive themselves, their families, or their environments as adequately prepared. The interview data provided concrete examples of this discrepancy. Students were often able to explain what should be done during or after an earthquake, but many also reported that emergency kits had not been prepared, plans were incomplete, or preparedness actions had not been maintained. This gap may be shaped by several interrelated factors, including optimistic bias, limited self-efficacy, family-level inaction, and the practical difficulty of sustaining preparedness behaviours in everyday life. Previous research has similarly indicated that although students may demonstrate awareness of natural hazards, translating this awareness into concrete behavioural actions often requires deeper engagement with scientific understanding and decision-making processes (Cerulli & Holbrook, 2019). These findings reinforce the argument that disaster education should move beyond awareness-raising and focus more directly on behaviour change, routine practice, and family participation.

A moderate positive correlation was found between earthquake literacy and earthquake awareness, indicating that students with higher literacy also tend to demonstrate greater awareness. This finding supports the theoretical view that knowledge, attitudes, and preparedness competencies form an important basis for disaster awareness (Becker et al., 2013; Rahim & Wu, 2015). At the same time, the relationship was moderate rather than strong, suggesting that awareness is not shaped solely by literacy.

This is supported by the qualitative findings that students with stronger knowledge often expressed clearer awareness of protective actions and the importance of preparedness; however, they still did not always report sustained preparedness practices. This indicated that literacy can support awareness, but additional factors such as family support, emotional regulation, prior experience, and perceived control are also critical. Accordingly, strengthening earthquake preparedness requires attention not only to what students know, but also to the conditions that enable them to act on that knowledge.

The qualitative findings deepened the interpretation of the quantitative results in several ways. First, they showed that students' knowledge was largely procedural and focused on

immediate response behaviours rather than deeper conceptual understanding. Second, they revealed uncertainty and lack of confidence beneath relatively high survey scores, suggesting that students may know the correct responses without fully feeling prepared. Third, they highlighted the central role of families in shaping preparedness behaviours, indicating that students' readiness is strongly influenced by household practices rather than individual knowledge alone. Finally, they demonstrated that emotional responses to earthquakes vary considerably and that social support, especially from family members, is important in coping with fear and anxiety.

Taken together, the findings highlight the multidimensional nature of adolescents' disaster preparedness. While students generally demonstrate strong cognitive knowledge of protective actions, translating this knowledge into sustained preparedness behaviours remains a persistent challenge. These results reinforce previous research indicating that disaster education programmes must move beyond awareness-raising and emphasise experiential learning, repeated practice, and family engagement in order to foster long-term preparedness behaviours.

Conclusion and Implications

First, regarding the assessment of students' earthquake literacy and awareness levels, the findings indicated that students demonstrated moderate to high levels of earthquake literacy and generally positive earthquake awareness. This study provides important evidence that while students demonstrated strong cognitive knowledge and familiarity with protective behaviours, their affective engagement with earthquake risks remained comparatively moderate and the lowest among the three dimensions. This finding suggests a potential imbalance in disaster education, where emotional preparedness may receive comparatively less emphasis than cognitive and behavioural components.

Second, regarding demographic differences in earthquake literacy and awareness, significant gender differences were observed, with female students reporting higher levels of affective and behavioural literacy as well as higher earthquake awareness. In addition, younger students (5th–6th grades) demonstrated higher literacy and awareness scores than older students (7th–8th grades), suggesting that earthquake-related knowledge and awareness may decline if not reinforced over time. These findings indicate that both gender and grade level are associated with variations in earthquake literacy and awareness, with the observed age-related pattern pointing to the need for sustained reinforcement across grade levels.

Third, with respect to the relationship between earthquake literacy and awareness, a moderate positive relationship between earthquake literacy and earthquake awareness was identified, indicating that higher levels of knowledge and perceived competencies are associated with greater awareness of earthquake risks. This finding is consistent with theoretical perspectives suggesting that literacy and awareness are closely related constructs, thereby highlighting the importance of comprehensive literacy development in disaster education.

These findings highlight the importance of strengthening school-based disaster education programmes. Based on the identified affective literacy gap, earthquake education should be implemented as a continuous and developmentally appropriate process across grade levels and should address cognitive, affective, and behavioural dimensions simultaneously. In particular, educational programmes should place greater emphasis on emotional coping, self-efficacy, and the translation of knowledge into sustained preparedness behaviours. To address the observed age-related decline in literacy and awareness, educational interventions must incorporate systematic reinforcement strategies and grade-appropriate curricula that maintain engagement throughout students' academic progression. The results also underscore the role of families in shaping students' preparedness practices, suggesting that school-based disaster education should involve parents and communities more actively. Given the documented gender differences,

educators should consider differentiated instructional approaches that enhance affective and behavioural engagement among male students while maintaining the strengths observed in female students.

Future research should examine earthquake literacy and preparedness across diverse regional contexts and evaluate the effectiveness of school-based disaster education interventions designed to strengthen students' long-term preparedness behaviours and resilience. Additionally, longitudinal studies are needed to track the persistence of earthquake literacy over time and to identify the specific mechanisms underlying the observed decline in older students. Intervention studies should also investigate the optimal balance between cognitive, affective, and behavioural components in disaster education curricula, with particular attention to strategies that enhance emotional preparedness and sustained behavioural change.

Study Limitations

Several limitations of this study should be acknowledged. First, the study was conducted in a single lower-secondary school in Çanakkale, Türkiye, which may limit the generalizability of the findings to other regions or educational contexts. Second, the quantitative data were based on self-reported measures, which may be influenced by social desirability or students' subjective perceptions of their knowledge and preparedness. Third, the cross-sectional design of the study precludes causal inference about the relationship between earthquake literacy and earthquake awareness. Future research should employ longitudinal or intervention-based designs to examine how disaster education programmes influence literacy and preparedness over time.

Declaration of Interest

The authors declare no competing interests.

Statement on the Use of Generative AI

During the preparation of this manuscript, ChatGPT (OpenAI, GPT-5.3) and Grammarly were used solely for language editing and proofreading. All AI-assisted outputs were reviewed and approved by the authors, who take full responsibility for the final manuscript.

References

- AFAD. (2023). *Türkiye deprem tehlike haritası* [Turkey earthquake hazard map]. Afet ve Acil Durum Yönetimi Başkanlığı. <https://www.afad.gov.tr>
- Arslan, K., Görgülü Arı, A., & Hayır Kanat, M. (2023). Ortaokul öğrencilerine yönelik deprem okuryazarlığı ölçeği geliştirme çalışması [Earthquake literacy scale development study for secondary school students]. *Türk Coğrafya Dergisi*, 83, 163–178. <https://doi.org/10.17211/tcd.1274001>
- Bachman, L. F. (2004). *Statistical analyses for language assessment*. Cambridge University Press.
- Becker, J. S., Paton, D., Johnston, D. M., Ronan, K. R., & McClure, J. (2013). The role of prior experience in informing and motivating earthquake preparedness. *International Journal of Disaster Risk Reduction*, 22, 179–193. <https://doi.org/10.1016/j.ijdr.2017.03.006>
- Byrne, B. M. (2010). *Structural Equation Modeling with AMOS: Basic concepts, applications, and programming*. Taylor and Francis Group Publication.
- Cerulli, D. A., & Holbrook, J. B. (2019). Exploring the effect of NOS/NOT learning and dispositions on undertaking behavioural actions in the case of natural hazards. *Journal of Baltic Science Education*, 18(4), 519–536. <https://doi.org/10.33225/jbse/19.18.519>

- Codreanu, T. A., Celenza, A., & Jacobs, I. (2014). Does disaster education of teenagers translate into better survival knowledge, knowledge of skills, and adaptive behavioral change? A systematic literature review. *Prehospital and Disaster Medicine*, 29(6), 629–642. <https://doi.org/10.1017/S1049023X14001083>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage Publications.
- Dewi, N. W. R. U., Jan, W., & Kim, M. (2025). Risk perception and response to natural hazards within science curriculum. *Journal of Baltic Science Education*, 24(2), 239–254. <https://doi.org/10.33225/jbse/25.24.239>
- Ersoy, Ş., & Koçak, A. (2016). Disasters and earthquake preparedness of children and schools in Istanbul, Turkey. *Geomatics, Natural Hazards and Risk*, 7(4), 1307–1336. <https://doi.org/10.1080/19475705.2015.1060637>
- Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. McGraw-Hill Education.
- George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference* (4th ed.). Allyn & Bacon.
- Glass, G. V., Peckham, P. D., & Sanders, J. R. (1972). Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance. *Review of Educational Research*, 42(3), 237–288. <https://doi.org/10.3102/00346543042003237>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis: A global perspective* (7th ed.). Prentice Hall.
- Henson, H., McDaniel, J., Subramanian, R., & Edwards, T. (2020). Intervention and assessment of earthquake knowledge at rural schools near the New Madrid seismic zone, USA. *Natural Hazards*, 104(2), 1315–1329. <https://doi.org/10.1007/s11069-020-04215-1>
- Izadkhah, Y. O., & Gibbs, L. (2015). A study of preschoolers' perceptions of earthquakes through drawing. *International Journal of Disaster Risk Reduction*, 14, 132–139. <https://doi.org/10.1016/j.ijdr.2015.06.002>
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14–26. <https://doi.org/10.3102/0013189X033007014>
- Katada, T., & Kanai, M. (2016). The school education to improve the disaster response capacity: A case of “Kamaishi Miracle.” *Journal of Disaster Research*, 11(5), 845–856. <https://doi.org/10.20965/jdr.2016.p0845>
- Karancı, A. N., Aksit, B., & Dirik, G. (2005). Impact of a community disaster awareness training program in Turkey: Does it influence hazard-related cognitions and preparedness behaviors. *Social Behavior and Personality*, 33(3), 243–258. <https://doi.org/10.2224/sbp.2005.33.3.243>
- Kuloğlu, A., Tutuş, F., & Özer, M. (2024). Secondary school students' disaster preparedness perception: A mixed method approach. *Sakarya University Journal of Education*, 14(3), 563–580. <https://doi.org/10.19126/suje.1382630>
- Kvale, S., & Brinkmann, S. (2015). *Interviews: Learning the craft of qualitative research interviewing*. Sage.
- Mahanoğlu, S., & Balcı, S. (2025). Ortaokul öğrencileri için deprem farkındalığı ölçeği: Geçerlik ve güvenirlik çalışması [Earthquake awareness scale for secondary school students: Validity and reliability study]. *Mevzu: Sosyal Bilimler Dergisi*, 13, 991–1015. <https://doi.org/10.56720/mevzu.1610681>
- Maulana, T. I., Rahmawati, A., Syamsi, M. I., Setyawan, E. A., Fauzi, M. A. A., & Djola, B. M. (2023). Improving the awareness of earthquake natural disasters preparedness of SMP Muhammadiyah Sewon students. *Proceeding International Conference of Community Service*, 1(2), 856–862..
- Mutch, C. (2014). The role of schools in disaster preparedness, response and recovery: What can we learn from the literature? *Pastoral Care in Education*, 32(1), 5–22. <https://doi.org/10.1080/02643944.2014.880123>
- Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (7th ed.). Routledge.

- Paton, D., & Johnston, D. (2001). Disasters and communities: vulnerability, resilience and preparedness. *Disaster Prevention and Management: An International Journal*, 10(4), 270–277. <https://doi.org/10.1108/EUM0000000005930>
- Pituch, K. A., & Stevens, J. P. (2016). *Applied multivariate statistics for the social sciences* (6th ed.). Routledge.
- Rahim, N. B. A., & Wu, B. S. (2015). Disaster prevention literacies: Assessing the knowledge, skills and attitude of Taiwanese students for an earthquake disaster. *HSSE Online*, 4(1), 30–40.
- Ronan, K. R., & Johnston, D. M. (2005). *Promoting community resilience in disasters: The role for schools, youth, and families*. Springer.
- Santos-Reyes, J., Santos-Reyes, G., Gouzeva, T., & Velazquez-Martinez, D. (2017). Schoolchildren's earthquake knowledge, preparedness, and risk perception of a seismic-prone region of Mexico. *Human and Ecological Risk Assessment: An International Journal*, 23(3), 494–507. <https://doi.org/10.1080/10807039.2016.1188368>
- Setyaningrum, N., Nobel Bistara, D., Setyorini, A., Nur Adkhana Sari, D., Yulia Purwitaningtyas, R., & Samaran, E. (2025). Determinants of earthquake preparedness among junior high school students in Bantul Regency, Yogyakarta: An analysis of demographic and socioeconomic factors. *Journal of Human Behavior in the Social Environment*, 1–16. <https://doi.org/10.1080/10911359.2025.2481974>
- Shaw, R., Shiwaku, K., Kobayashi, H., & Kobayashi, M. (2004). Linking experience, education, perception, and earthquake preparedness. *Disaster Prevention and Management*, 13(1), 39–49. <https://doi.org/10.1108/09653560410521689>
- Solikhah, M., & Purwito, D. (2024). Community preparedness for earthquake natural disasters on empirical study. *Proceedings Series on Health & Medical Sciences*, 5, 151–155. <https://doi.org/10.30595/pshms.v5i.978>
- Stevens, J. P. (2012). *Applied multivariate statistics for the social sciences* (5th ed.). Routledge.
- Sutrisno, D., Suwarno, Y., Rahadiati, A., Habibie, M. I., Putra, P. K., Prayogi, H., ... & Kosasih, A. (2025). Community preparedness for earthquake disasters: A preliminary assessment of awareness and disaster infrastructure response in Cianjur, West Java-Indonesia. *F1000Research*, 13, Article 256. <https://doi.org/10.12688/f1000research.143577.3>
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Pearson.
- Toprak-Dereli, D., & Savasci-Acikalın, F. (2018). Middle school students' conceptual understanding of earthquakes. *SHS Web of Conferences*, 48, Article 01024. <https://doi.org/10.1051/shsconf/20184801024>
- Tuswadi, T., & Hayashi, T. (2014). Disaster prevention education in Merapi volcano area primary schools: Focusing on students' perception and teachers' performance. *Procedia Environmental Sciences*, 20, 668–677. <https://doi.org/10.1016/j.proenv.2014.03.080>
- Wei, B., Su, G., & Li, Y. (2020). Evaluating the cognition and response of middle/high school students to earthquake—A case study from the 2013 Mw6.6 Lushan earthquake-hit area, China. *International Journal of Disaster Risk Reduction*, 51, Article 101825. <https://doi.org/10.1016/j.ijdrr.2020.101825>
- Widyusuf, L., Muktiarni, M., & Mupita, J. (2022). Earthquake disaster preparedness for students of junior high school. *ASEAN Journal of Science and Engineering Education*, 2(2), 129–136. <https://doi.org/10.17509/ajsee.v2i2.38679>
- Wikan, P. A., Kinanthi, R., & Khoir, A. Z. (2022). Understanding the roles of experience, self-efficacy, and attitude in SIBAT community for earthquake disaster preparedness. *Social, Humanities, and Educational Studies (SHES): Conference Series*, 5(4), 206–211.
- Yeon, D. H., Chung, J. B., & Im, D. H. (2020). The effects of earthquake experience on disaster education for children and teens. *International Journal of Environmental Research and Public Health*, 17(15), Article 5347. <https://doi.org/10.3390/ijerph17155347>
- Yildiz, A., Teeuw, R., Dickinson, J., & Roberts, N. (2020). Children's earthquake preparedness and risk perception: A comparative study of two cities in Turkey, using a modified PRISM approach. *International Journal of Disaster Risk Reduction*, 49, Article 101666. <https://doi.org/10.1016/j.ijdrr.2020.101666>
- Yilmaz, E., & Yildirim, A. (2023). Too little, too late: Addressing the roles of a school safety programme in earthquake preparedness of elementary students in Turkey. *Asia Pacific Journal of Education*, 43(4), 1049–1070. <https://doi.org/10.1080/02188791.2021.1965956>

Received: *March 27, 2026*

Revised: *April 18, 2026*

Accepted: *May 25, 2026*

Cite as: Yalçinkaya-Önder, E., & Tatli, S. (2026). Earthquake literacy and awareness among lower-secondary school students. *Problems of Education in the 21st Century*, 84(3), 417–444. <https://doi.org/10.33225/pec/26.84.417>

Eylem Yalçinkaya-Önder
(Corresponding author)

PhD, Associate Professor, Department of Mathematics and Science Education,
Çanakkale Onsekiz Mart University, Çanakkale, Türkiye.
E-mail: eylemyk@gmail.com
ORCID: <https://orcid.org/0000-0003-1306-9931>

Selin Tatli

MSc, School of Graduate Studies, Çanakkale Onsekiz Mart University,
Çanakkale, Türkiye.
E-mail: [slingzn@gmail.com](mailto:singzn@gmail.com)
ORCID: <https://orcid.org/0009-0001-8252-9615>



AGRICULTURAL AWARENESS EDUCATION FOR STUDENTS WITH MILD INTELLECTUAL DISABILITIES: AN ACTIVITY-BASED APPROACH

Taner Küçük

Provincial Directorate of National Education, Türkiye
E-mail: tanerk22.te@gmail.com

İsmail Satmaz

Çanakkale Onsekiz Mart University, Türkiye
E-mail: ismailsatmaz@comu.edu.tr

Abstract

This study aimed to examine the effects of an activity-based agricultural awareness education program on the agricultural awareness of middle school students with mild intellectual disabilities (MID). The study was conducted using a convergent mixed-methods design embedded within a design-based research framework. Ten agricultural activities were developed and implemented over 25 teaching hours with 12 students aged 11 to 15. The program integrated direct teaching, video-based modeling, hands-on tasks, systematic reinforcement, and peer interaction to support conceptual learning and social participation. Data were collected through the MID Agricultural Awareness Test and semi-structured interviews with students and teachers. Quantitative results showed a statistically significant increase in students' agricultural awareness from pretest ($M = 15.75$, $SD = 2.86$) to posttest ($M = 18.41$, $SD = 1.56$), $t(11) = 4.804$, $p = .003$. Qualitative results indicated that students developed practical knowledge about soil, plants, harvesting, and food preparation, while teachers reported increased engagement, cooperation, environmental awareness, and peer interaction during the program. These results should be interpreted cautiously because the study used a small sample and a single-group pretest–posttest design. The results provide preliminary evidence that activity-based agricultural awareness education may help connect science-related content with real-life experiences for students with MID.

Keywords: agricultural awareness; activity-based learning; special education; experiential learning; mild intellectual disability.

Introduction

According to data from the European Commission (EC), between 1 percent and 3 percent of the world's population is affected by intellectual disability. More recent global estimates indicate that approximately 107.6 million people, corresponding to 1.74 percent of the world population, live with intellectual disability according to the Global Burden of Disease (GBD) study (GBD, 2020; Nair et al., 2022; Yang et al., 2024). Intellectual disability is classified into different levels of severity, one of which is mild intellectual disability (MID) (Maulik et al., 2011; Schalock and Luckasson, 2015).

MID is characterized by significant limitations in both intellectual functioning, including reasoning and problem solving, and adaptive behavior, including daily living and social skills, as defined by the American Psychiatric Association (APA) (APA, 2013). For this reason, individuals with MID require systematic support not only for cognitive development but also for social participation and social development (Wang et al., 2024).

Academic knowledge that is closely connected to everyday life plays a crucial role in supporting social development (Durlak et al., 2011). Social skills refer to behaviors that individuals frequently encounter in their environment and that enable meaningful participation in social life when acquired (Christ et al., 2017). Being informed about work-related skills and everyday activities in one's immediate environment enhances individuals' opportunities for social inclusion and community participation (Khoronzhevych et al., 2021). Accordingly, well-designed instructional activities can increase both the social acceptance and social participation of students with MID.

The region in which this study was conducted is well known in Türkiye for its agricultural production. Increasing students' awareness of agricultural production and agricultural products can therefore provide meaningful opportunities for students with MID to engage with their social environment and to acquire practical life knowledge that supports independent living, as emphasized by the American Association on Intellectual and Developmental Disabilities (AAIDD) (AAIDD, 2016). Moreover, agricultural awareness can create opportunities for career exploration among individuals with MID (Norris et al., 2025). Previous research emphasizes the importance of introducing agricultural education from the primary school level onward (Knobloch and Martin, 2002). However, lower-secondary textbooks contain only limited information about agricultural topics (Haşlıoğlu et al., 2011), and they rarely provide detailed explanations of how region-specific crops are grown, harvested, and used as products. Given this gap, it is important to examine the effects of specially designed agricultural activities on the agricultural awareness of students with MID.

Literature Review

Although research on science education for students with disabilities has increased, studies focusing specifically on science education for students with MID remain limited (Villanueva et al., 2012; Özgüç & Cavkaytar, 2015). Contemporary science education is typically book-centered and teacher-led, relying heavily on verbal explanations and visual representations of scientific concepts (Kızılaslan et al., 2020). However, there is still insufficient empirical evidence regarding which instructional approaches are most effective for teaching science content to students with MID (Apanasionok et al., 2019).

Existing research suggests that students with MID benefit most from structured, explicit, and multimodal instructional approaches. Peer-mediated interventions have been shown to improve both social and behavioral outcomes for learners with intellectual disabilities (Bowman-Perrott et al., 2021). Direct instruction has also been identified as a highly effective method for this population, particularly for acquiring functional and academic skills (Dessemontet et al., 2019; Eratay, 2020). In addition, video-based education has been found to be especially beneficial for students with MID, as it provides visual modeling, repetition, and opportunities for independent practice (Schroeder, 2023). Reinforcement strategies further enhance learning, with multiple studies demonstrating their positive effects on engagement, skill acquisition, and task persistence among students with MID (Matson & Boisjoli, 2009; Mirzamani et al., 2011; Johnson, 2018). Collectively, these results indicate that combining direct instruction, video modeling, reinforcement, and peer support creates an optimal learning environment for students with MID.

Agricultural sciences, as a subfield of science education, offer particularly rich opportunities for experiential and functional learning. A growing body of research indicates that agricultural and horticultural activities can support not only skill development but also emotional and social functioning in individuals with MID. For example, Joy et al. (2020) demonstrated that an eight-week succulent cultivation program led to significant improvements in emotional behavior, fine motor skills, and social skills among participants with MID. Similarly, Ulugöl

and Eratay (2020) showed that video modeling was highly effective in teaching seedling cultivation skills to students with MID, highlighting the value of visual and procedural support in agricultural instruction.

Evidence from broader farming-based interventions further supports the social and psychological benefits of agricultural activities for individuals with intellectual disabilities. A systematic review by Iancu et al. (2014) found that team-based agricultural practices had a meaningful positive impact on mental well-being, although the authors emphasized the need for additional research to clarify their social and vocational outcomes. More recently, Son et al. (2022) reported that horticultural programs improved work behaviors, adaptive functioning, and fine motor skills, while also strengthening social relationships among participants with intellectual disabilities.

Despite these promising results, most existing studies focus on upper-secondary or adult populations, leaving middle school students with MID largely underrepresented in the literature. This gap is particularly important given that, according to Piaget (1954), the transition toward formal operational thinking provides a critical window for introducing abstract concepts such as germination and plant growth. Therefore, there is a clear need for developmentally appropriate, activity-based agricultural instruction designed specifically for middle school students with MID.

Based on this gap, the problem addressed in the present study is the limited availability of developmentally appropriate, activity-based agricultural awareness education programs designed specifically for middle school students with mild intellectual disabilities. Therefore, this study aimed to examine the effect of an activity-based agricultural awareness education program on the agricultural awareness of middle school students with mild intellectual disabilities and to explore students' experiences during the implementation process. Accordingly, the study was guided by the following research questions:

1. Does the activity-based agricultural awareness education program significantly improve the agricultural awareness levels of middle school students with mild intellectual disabilities?
2. How do students with mild intellectual disabilities experience the activity-based agricultural awareness education program?
3. What changes are observed in students' engagement, cooperation, social communication, and environmental awareness during the implementation process?

Research Methodology

Design

This study employed a convergent mixed-methods design embedded within a design-based research (DBR) framework. This methodological combination was selected because the study involved both the development and the evaluation of an educational program for a specific learner group. A DBR framework was appropriate because the study did not test a previously standardized program; instead, it developed agricultural awareness activities through expert collaboration, literature-based planning, and classroom-based implementation. The convergent mixed-methods design was used because changes in students' agricultural awareness could not be fully understood through test scores alone. Quantitative data were used to examine whether students' awareness scores changed after the program, whereas qualitative data were used to explain how students experienced the activities and how teachers observed changes in participation, communication, and engagement.

The purpose of this approach was to develop, implement, and evaluate an educational intervention grounded in both theory and classroom practice. DBR was used to guide the systematic development of the agricultural awareness activities through expert collaboration and iterative refinement, while an evaluative case study design was used to examine how the intervention functioned in practice and what outcomes it produced (Merriam, 1998).

Figure 1
Steps of the Study



Quantitatively, a single-group pretest–posttest quasi-experimental design was used to examine changes in students’ agricultural awareness. Qualitatively, semi-structured interviews with students and teachers were conducted to capture experiences, social interaction, and perceived changes during the intervention. Quantitative and qualitative data were collected concurrently and integrated during interpretation to provide a comprehensive understanding of the intervention’s effects.

Setting and Participants

The study was conducted with 12 lower-secondary students diagnosed with mild intellectual disability (MID), aged between 11 and 15 years. Participants were enrolled in six different middle schools, and two students also received additional services from private special education and rehabilitation centers. Participation was based on voluntary consent, and purposive sampling was used to select students who met the study criteria and matched the goals of the intervention (Nikolopoulou, 2023).

The instructional activities were implemented in a structured school-based learning environment designed to minimize distractions and allow hands-on engagement with agricultural materials. This setting enabled students to interact with concrete tools, plants, and food materials while working individually and collaboratively.

Ethical Approval

Ethical approval for the study was obtained from the Çanakkale Onsekiz Mart University Social and Humanities Research Ethics Committee before data collection began (Approval date: 22 August 2025; Decision no: 49/72). Written informed consent was obtained from the students’ parents or legal guardians, and student assent was also sought before participation. Participation was voluntary, and students were informed that they could withdraw from the study at any stage without any negative consequences. To protect confidentiality, student and teacher identities were anonymized using codes such as S1–S12 and E1–E6. All activities were conducted in a structured school-based environment under teacher supervision, and the content of the activities was designed to be developmentally appropriate for students with mild intellectual disabilities.

Development of the Agricultural Awareness Program

The program development began with an analysis of middle school science textbooks focusing on plant growth and agricultural production. Although these materials covered basic concepts such as germination and plant growth, they lacked experiential, student-centered activities appropriate for learners with MID.

To address this gap, five structured online meetings were held between a special education specialist and an agricultural engineer. These expert consultations were combined with a review of literature on effective instructional strategies for students with MID. Both sources emphasized the importance of selecting activities that support functional life skills, social participation, and concrete learning.

Based on this process, ten agricultural activities were developed to represent the full agricultural cycle, from soil and plant care to harvesting and food preparation (Appendices 2). The activities were reviewed by three special education experts and three science education experts for content accuracy, developmental appropriateness, and instructional clarity. Revisions were made accordingly, and the finalized program was scheduled for 25 instructional hours.

Clarification of Key Social Constructs

Because this study examined several social outcomes during the activities, the terms social communication, social participation, and social skills were used with distinct meanings. Social communication refers to students' verbal and non-verbal interactions with peers and teachers during the activities. Social participation refers to students' active involvement in shared tasks and group-based learning processes. Social skills refers more broadly to observable behaviors such as sharing, helping, cooperation, turn-taking, and joint decision-making. These distinctions guided the interpretation of the interview data.

Data Collection Instruments

Three main instruments were used to collect quantitative and qualitative data: the MID Agricultural Awareness Test, student semi-structured interviews, and teacher semi-structured interviews.

The MID Agricultural Awareness Test was developed to measure students' knowledge and awareness of agricultural concepts and practices targeted in the intervention. The test consisted of 10 items rated on a three-point Likert-type scale, suitable for students with MID. Content validity was established through expert review by three special education specialists and three science education experts. Content validity ratios (CVR) ranged between 0.71 and 1.00, indicating strong content relevance. No items were removed following expert review. The instrument was piloted with two students, and no comprehension problems were identified. Test-retest reliability was examined using a two-week interval, yielding a Pearson correlation coefficient of $r = .78$, which indicates acceptable temporal stability.

Student interview protocols were designed to examine changes in agricultural awareness, social interaction, emotional responses, and engagement during the activities. Questions focused on what students learned, how they interacted with peers, which activities they found enjoyable or difficult, and how their feelings toward nature and farming changed. Instructor interviews focused on student motivation, attention, cooperation, communication, and behavioral changes observed throughout the program. All interview protocols were reviewed by three special education experts, one science education expert, and three curriculum specialists to ensure clarity, developmental appropriateness, and alignment with the study goals.

Data Collection Procedures

The agricultural awareness program was implemented across 25 teaching hours using evidence-based teaching strategies for students with MID, including direct teaching, video-based modeling, structured practice, and systematic reinforcement. To maximize engagement, students completed a reinforcement preference form, and their individually selected social reinforcers were used consistently throughout the teaching process (Table 1).

Table 1
Social Reinforcers Chosen by the Students

Student Number	Social Reinforcer	Student Number	Social Reinforcer
S1	Well done	S7	High-five
S2	Great job	S8	Very good
S3	Congrats	S9	Excellent
S4	Very good	S10	Congrats
S5	Well done	S11	Congrats
S6	Very good	S12	Great job

One representative activity was the Kitchen Workshop, in which students learned how agricultural products are transformed into food through hands-on preparation tasks (Appendices 1).

Before the intervention, the MID Agricultural Awareness Test was administered as a pretest. Throughout the implementation, daily semi-structured student interviews were conducted to monitor changes in learning, social interaction, and engagement. After the completion of the program, the test was re-administered as a posttest, and follow-up interviews were conducted with both students and teachers to capture perceived changes in agricultural awareness and social development.

Data Analysis

Quantitative data from the MID Agricultural Awareness Test were analyzed using paired-samples t-tests to examine changes between pretest and posttest scores. Descriptive statistics (means and standard deviations) were calculated to summarize students' agricultural awareness before and after the intervention. These analyses allowed the researchers to determine whether the activity-based program produced statistically significant improvements in agricultural knowledge.

Qualitative interview data were analyzed using thematic coding. Two researchers independently coded all transcripts, and inter-coder reliability was calculated using the Miles and Huberman (1994) formula, yielding 82% agreement, which indicates acceptable reliability. Disagreements were resolved through discussion to reach consensus. To enhance trustworthiness, multiple strategies were used, including method triangulation (quantitative tests, student interviews, and instructor interviews), source triangulation (students and teachers), and the use of direct quotations to support analytic interpretations. This combination of quantitative and qualitative evidence strengthened the credibility and confirmability of the results.

Research Results

Quantitative Results: MID Agricultural Awareness Test

As shown in Table 2, pretest–posttest scores on the MID Agricultural Awareness Test indicated an increase in students’ agricultural awareness after the intervention. Participants’ mean pretest score was 15.75 ($SD = 2.86$, $n = 12$), which increased to 18.41 on the posttest ($SD = 1.56$, $n = 12$). The difference between pretest and posttest scores was statistically significant, $t(11) = 4.804$, $p = .003$, suggesting that the activity-based program contributed to a meaningful improvement in agricultural awareness among students with MID.

Table 2

Pretest and Posttest Scores on the MID Agricultural Awareness Test ($n=12$).

Variable	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Pretest	12	15.75	2.86	11	4.804	.003
Posttest	12	18.41	1.56			

Results from Student Interview

Agricultural Awareness

To examine students’ agricultural awareness and social communication during the implementation, semi-structured interviews were conducted at the end of each day. To elicit changes in agricultural awareness, students were first asked: “Did you do anything for the first time today? Can you explain something you learned thanks to this activity? What did you learn that you did not know before?” Students were also asked: “After the activities, what changed in your thoughts about nature, soil, and plants? What did you realize you had misunderstood or known incompletely?” The codes developed from students’ responses are presented in Table 3.

Table 3
Student Views Related to the Agricultural Awareness Category

Question	Code	Students
1- What was something you did for the first time in today's activities? Can you describe something you learned through this activity? What did you learn that you had not known before?	Making a salad	S1, S7
	Harvesting vegetables	S2, S3, S8, S12
	Smart irrigation	S10
	Adequate irrigation	S2
	Drama/role-play	S1
	Animals	S1
	Sowing seeds	S6, S7
	Painting pots	S4
	Soil components and soil knowledge	S1, S5, S6, S10
	Insects	S9, S10, S11
	Local agricultural products	S11
	Catching butterflies	S12
	Using a tablet-based mobile app	S3
2- What changed in your thoughts about nature, soil, and plants after the activity? Can you explain what you had known incorrectly or incompletely before?	Realizing misconceptions	S1, S7, S10
	Misunderstood growing conditions	S9
	Valuing/appreciation	S3
	Strengthened love for nature	S10
	Feeling good	S5
	Loving nature more	S9
	Helping others	S1
	Protecting nature	S3

Students' responses indicated that several agricultural concepts and practices were learned for the first time. For example, after the second day, S2 stated, "Something I did for the first time... I learned about sand, I learned about soil," reflecting a new understanding of soils.

Similarly, S10 reported, “I didn’t know what soil was like,” again pointing to first-time learning related to soil. After the fifth day, S8 noted, “Picking fruits and vegetables from the garden,” indicating that harvesting was a new experience. S3 emphasized first-time technology-mediated plant identification, stating, “Yes, I used those tablets to take a picture of a plant for the first time,” suggesting an initial experience with a tablet-supported plant identification application. In addition, after the fifth day, S1 reported, “I guess the first thing you did was making a salad,” indicating first-time participation in food preparation linked to agricultural products.

Students also described changes in awareness that extended beyond factual knowledge to include social and environmental values. After the fourth day, S1 stated, “Being respectful to others. Helping someone when they fall,” suggesting that the activities also supported prosocial awareness. After the third day, S3 explained, “When I see nature, I think about not having fires and protecting nature. I don’t want fires to happen,” indicating increased environmental responsibility. Practical agricultural knowledge also appeared in students’ accounts. After the fifth day, S10 described learning a more accurate harvesting technique: “Normally I pulled it, but the teacher explained... When you lift it up and twist it like this, it comes off anyway,” reflecting a shift from pulling to twisting during eggplant harvesting. Similarly, S9 stated, “It was the first time I learned that watermelons come out of the soil,” indicating new understanding about crop growth. Some students also described increased positive affect toward nature, such as S10 saying, “My love increased,” and S9 stating, “It made me love nature more,” after the third day.

Social Communication and Collaboration

To examine social communication, students were asked: “Did you work together with your friends today? What did you do? Was it easy to make decisions together?” Codes derived from these responses are presented in Table 4.

Table 4
Student Views Related to the Social Communication Category

Question	Code	Students
1- Did you work together with your friends today? What did you do? Was it easy to make decisions together?	Task distribution was easy	S7, S3
	Being together was nice	S4
	Working together was enjoyable	S3
	Social bonding/closeness	S2

Overall, students’ responses suggested that collaboration was feasible and often enjoyable. For example, after the fifth day, S3 stated: “*While making salad, we decided who would chop and who would do what. It was easy,*” highlighting task distribution and decision-making. After the third day, S4 noted: “*What made me happy was hanging out together at the greengrocer’s, sharing,*” emphasizing social interaction and sharing. S3 also described enjoyment in shared creative work: “*Putting the flowers in the container and decorating it was nice; I liked it,*” which reflected positive peer interaction during joint activities. In a similar vein, S2 expressed shared identity and bonding: “*We proudly painted it. Since we are both Beşiktaş fans, we made it Beşiktaş,*” indicating that collaboration facilitated social closeness through common interests.

Experiences and Emotions During the Activities

To explore students' experiences, they were asked: "What made you happiest during the activities?" followed by: "Were there things that were difficult for you? Why do you think you had difficulty?" They were also asked: "What interested you most today?" and "What emotions did you experience during the activity?" The codes developed from responses are shown in Table 5.

Table 5
Student Views Related to the activity process

Question	Code	Students
1- What made you the happiest during the activities? Can you explain?	Drawing/painting pictures	S1, S12
	Making a salad	S12
	Harvesting vegetables	S1, S4
	Planting flowers	S12
	Decorating pots	S5
	Socializing	S7
	Coloring/painting	S3, S8, S12
2- Were there any things that were difficult for you during the activity? Why do you think you had difficulty?	Catching animals	S1, S4
	Mathematical calculations	S12
	None (no difficulties)	S1, S2, S3, S7
3- What attracted your attention the most during today's activities? Can you explain?	Harvesting vegetables	S10
	Harvesting peppers	S7
	Drama/role-play	S12
	Selling	S10
	Being a vendor/market seller	S1, S2
	Smart irrigation	S4
	Planting seedlings	S5
	Painting pots	S2
	Working together	S4
	Flower types	S12
	Walking in nature/outdoor exploration	S1
4- What emotions did you experience during the activity?	Surprised	S2, S5, S12
	Excited	S12
	Happy	S1, S7, S10
	Cheerful	S4
	Fun/enjoyable	S12

Students frequently reported enjoyment from hands-on and role-based tasks. For example, S4 described: “We did drama... We drew fruits like figs and grapes, and we did a marketplace role-play,” suggesting that role-play and drawing were highly engaging. On the fifth day, S12 stated simply, “Making salad,” and S1 reported being happy “because we picked fruits and vegetables.” On the third day, S8 stated: “Seeing seeds, planting seeds in a pot, painting,” reflecting enjoyment of sensory and craft-based components. Another student, S4, also reported enjoyment “when catching animals,” pointing to interest in activity elements involving observation and interaction with living organisms.

In terms of difficulties, students’ responses indicated that challenges were not widespread but emerged in tasks requiring calculation. After the fifth day, S12 stated: “I got confused when calculating the money,” suggesting difficulty with mathematical operations. In contrast, S5 reported: “There wasn’t anything I struggled with,” and S1 similarly reported no difficulties after the first and second days.

Students’ interests were strongly oriented toward harvesting and real-life tasks. For instance, S10 stated: “I picked tomatoes and peppers, and I also made a salad,” indicating that collecting produce and preparing food were particularly interesting. On the fifth day, S2 noted interest in “being a vendor,” and S1 stated: “I walked around; I liked it a lot,” suggesting that exploring outdoor environments was motivating. Some students also expressed surprise and joy related to first-time experiences. For example, S5 stated: “Because I never picked anything before... that surprised me,” indicating novelty and emotional engagement. S4 reported happiness from shared time at the greengrocer’s and from eating what they prepared together: “Because we ate the food we collected and made together. I felt cheerful.” Similarly, S12 stated: “I had fun with my friends during the activities,” highlighting the emotional value of peer interaction.

Results From Instructor Interview

After the implementation, semi-structured interviews were conducted with teachers to capture observations regarding students’ motivation, participation, social communication, collaboration, and attention. Teachers were asked: (1) how they observed students’ motivation and participation, (2) whether they observed changes in students’ social communication, (3) how they evaluated group work and collaboration skills, and (4) whether students’ attention and focus differed during the program. The codes derived from teachers’ responses are presented in Table 6.

Table 6
Teacher Views During the Project on Students' Social Communication

Question	Code	Teacher
1- How did you observe the students' motivation and participation levels during the activities? Please explain in detail.	High motivation and active participation	E1, E3, E5, E6
	Improvement over time	E4, E6
	Social learning effect	E1, E5
2- Did you observe any change in the students' social communication skills during the project process? If yes, can you explain this change with examples?	Increased social communication	E1, E2, E3
	Sharing	E1, E2
	Reduced shyness	E4, E6
	Social cohesion among students from different schools	E2, E3
3- How did you observe the students' group work and cooperation skills? Please explain in detail.	Cooperation/helping each other	E2, E3
	Adaptation and inclusion	E1, E5
	Enjoyment	E5, E6
4- Did you observe any differences in the students' attention span or focusing skills? Please explain in detail.	Difference between theoretical vs. practical sessions	E2, E3
	Increased attention over time	E4, E5
	Effect of visual and concrete materials	E4
	Interest-based activities	E5
	Ability to recall/restate information	E1

Overall, teachers emphasized high motivation and participation. For example, E1 stated: "Students participated voluntarily in all activities," and E3 noted: "Each student was looking for an opportunity to show themselves," which reflected strong engagement. Teachers also described improvement over time. E4 stated that students' focus was high and that they could recall and express information from the previous day more clearly on the next day. E6 similarly reported: "Students were very interested in the activities. Their motivation was high, and they actively participated in every stage," indicating sustained engagement. Teachers further suggested that participation increased when students were directly included and when activities were experiential and visually supported. For example, E5 described a student who initially only observed on the first day but later became an active volunteer, which was interpreted as increased motivation over time.

Regarding social communication, teachers consistently reported positive change. E1 stated that students learned to communicate strongly with both teachers and peers, while E2 noted that communication was strong during shared tasks. E3 emphasized that students engaged in more dialogue, respected turn-taking, and attended to peers' speaking rights. Teachers also highlighted specific social behaviors such as sharing materials, mutual help, and reduced shyness. For example, E2 described how students exchanged colors and helped one another during a pot painting activity, while E4 observed that students who initially hesitated to speak became more communicative as activities progressed. E6 similarly noted that students were anxious and shy on the first day but became more comfortable and participatory by the final day.

Teachers also reported that students from different schools successfully socialized and formed positive peer relations.

In terms of collaboration, teachers reported frequent cooperation and mutual assistance. For example, E3 observed that during planting tasks, students helped one another in sequence by adding soil, holding the plant, and watering it. Teachers also noted that students adapted easily to group work, completed tasks collaboratively, and appeared to enjoy working together.

Finally, teachers described differences in attention depending on activity format. E2 reported that students' attention during theoretical explanations was brief, whereas attention and persistence were notably higher during practical tasks. Similarly, E3 emphasized that students sustained attention longer during direct, hands-on activities. Several teachers reported that attention increased over time, and that visual and concrete materials supported focus. Teachers also noted that interest-based activity design facilitated attention, and that students were able to recall and repeat learning from previous sessions, indicating retention.

Discussion

The students' posttest scores on the MID Agricultural Awareness Test were higher than their pretest scores after the activity-based agricultural awareness education program. This result indicates a positive within-group change in agricultural awareness. However, because the study did not include a control group, the increase should not be interpreted as definitive evidence that the program alone caused the improvement. It is more appropriate to state that the students showed measurable progress after participating in the program.

A possible reason for this progress is the concrete and repeated nature of the activities. Students with mild intellectual disabilities often need visible materials, guided practice, repetition, and immediate feedback when learning new concepts. In this study, agricultural concepts such as soil, irrigation, planting, harvesting, and food preparation were not presented only through verbal explanation. They were supported through hands-on tasks, video-based modeling, direct teaching, structured practice, and reinforcement. This may have helped students connect abstract agricultural concepts with observable actions and real objects.

This interpretation is compatible with previous research on teaching students with intellectual disabilities. Studies have shown that direct teaching, video modeling, reinforcement, and peer-supported activities can support learning, engagement, and skill acquisition among students with intellectual and developmental disabilities. The present results also align with agricultural and horticultural studies reporting that cultivation, planting, and garden-based activities may contribute to functional skills, social interaction, and emotional engagement in individuals with intellectual disabilities. However, most of these studies have focused on adults, vocational contexts, or older students. The present study adds a school-based middle school perspective to this literature.

The qualitative data help explain what changed beyond the test scores. Students reported first-time experiences such as learning about soil, planting seeds, harvesting vegetables, using a tablet-based plant identification application, and preparing salad from agricultural products. These responses suggest that the program created learning opportunities that are difficult to obtain through textbook-based science teaching alone. For students with MID, this type of learning may be especially useful because it links school knowledge with daily life, food, local production, and environmental observation.

Social communication was another area in which positive change was observed. Students described working together, sharing tasks, making decisions with peers, and enjoying group activities. Teachers also reported increased participation, reduced shyness, stronger peer interaction, and more cooperative behavior. These results are consistent with studies indicating that structured peer interaction and activity-based learning can support social and behavioral

outcomes for students with intellectual disabilities. In the present study, the social effects may have emerged because the activities required students to produce something together, such as decorating pots, planting, harvesting, preparing food, or role-playing a marketplace.

The results related to environmental awareness should be interpreted carefully. Some students stated that they began to think more about nature, plants, and environmental protection. These statements do not prove a stable or long-term change in environmental attitudes. Still, they show that the activities encouraged students to talk about nature and agricultural production in a more reflective way. This is important because environmental and agricultural topics can remain abstract when taught only through written or visual materials. Hands-on agricultural activities may make these topics easier for students with MID to understand and discuss.

The results also showed that not all parts of the program were equally easy for students. One student reported difficulty with money-related calculations during the marketplace activity. This difficulty is not surprising, as students with MID may experience challenges in abstract reasoning and numerical processing. The finding suggests that agricultural awareness activities involving calculation, pricing, or market simulation should include additional supports such as visual price cards, step-by-step prompts, simplified numbers, teacher modeling, and peer assistance.

The study has several limitations that affect the interpretation of the results. The sample was small and included only 12 students. The design was a single-group pretest–posttest design, so maturation, repeated testing, teacher effect, or other uncontrolled factors may have contributed to the observed change. The intervention was also short-term, and no follow-up measurement was conducted. Therefore, it is not possible to determine whether the gains were maintained over time. In addition, the MID Agricultural Awareness Test was developed for this study, which limits comparison with other studies using standardized measures.

Despite these limitations, the study provides preliminary evidence that activity-based agricultural awareness education may support agricultural knowledge, participation, and peer interaction among middle school students with MID. The main value of the program appears to lie in its use of concrete materials, repeated practice, social interaction, and real-life agricultural tasks. Future studies should test similar programs with larger samples, comparison groups, longer implementation periods, and follow-up assessments. Research comparing different types of agricultural activities would also help clarify which components are most useful for students with MID. Another limitation concerns the MID Agricultural Awareness Test. Although the test was reviewed by experts and showed acceptable test–retest reliability, it was a researcher-developed instrument with only 10 items. Therefore, it may not cover the full breadth of agricultural awareness, and the results are not directly comparable with studies using standardized instruments. The local context should also be considered. Although the program was based on general principles of special education and experiential learning, its content was shaped by the agricultural characteristics of the region in Türkiye. Therefore, direct replication in other contexts may require adaptation to local crops, school resources, cultural practices, and available agricultural learning environments.

Conclusions and Implications

This study suggests that an activity-based agricultural awareness education program may support agricultural knowledge and social participation among middle school students with mild intellectual disabilities (MID). Students' posttest scores were higher than their pretest scores, and interview data indicated that they participated actively in hands-on activities such as planting, harvesting, irrigation, and food preparation. Teachers also reported increased participation, cooperation, peer interaction, and reduced shyness during the program. These results should be interpreted within the methodological limits of the study. The research was conducted with

a small and relatively homogeneous group of students and used a single-group pretest–posttest design without a control group. Therefore, the results do not allow strong causal claims. The intervention was also limited in duration, and no follow-up measurement was conducted to examine whether the observed gains were maintained over time. Another limitation concerns the MID Agricultural Awareness Test. Although the test was reviewed by experts and showed acceptable test–retest reliability, it was a researcher-developed instrument with only 10 items. Therefore, it may not cover the full breadth of agricultural awareness, and the results are not directly comparable with studies using standardized instruments. The local context should also be considered. Although the program was based on general principles of special education and experiential learning, its content was shaped by the agricultural characteristics of the region in Türkiye. Direct replication in other contexts may therefore require adaptation to local crops, school resources, cultural practices, and available agricultural learning environments.

Despite these limitations, the study provides preliminary evidence that agricultural awareness activities may be useful in connecting science-related content with everyday life for students with MID. Such activities may help teachers use concrete materials, visual support, structured practice, peer interaction, and reinforcement in ways that support both learning and participation. For schools, small-scale agricultural learning spaces such as gardens or classroom-based planting areas may offer practical opportunities for experiential learning, provided that the activities are adapted to students' developmental needs and local conditions.

Future studies should examine similar programs with larger and more diverse samples, comparison or control groups, longer implementation periods, and follow-up assessments. Further research may also compare different types of agricultural activities to identify which components are most useful for supporting agricultural awareness, social communication, and participation among students with MID.

Acknowledgements

CRedit Author Contributions

TK: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Visualization. İS: Supervision, Methodology, Validation, Resources, Writing – Review & Editing, Project Administration.

Funding

This study was supported by TÜBİTAK under project number 125B509.

Conflict of interest

The authors declare no conflict of interest.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available because individual participant consent for data sharing was not obtained but are available from the corresponding author on reasonable request and in accordance with ethical approval.

Ethics Approval

Ethical approval for this study was obtained from the Çanakkale Onsekiz Mart University Social and Humanities Research Ethics Committee (Approval date: 22 August 2025; Decision no: 49/72).

Generative AI Tool Use

OpenAI's ChatGPT (version 5.2) was used to assist with language editing, proofreading, and improving the clarity and academic tone of the manuscript. The authors reviewed, verified, and take full responsibility for the final content of the manuscript.

References

- AAIDD. (2016). *Teaching students with disabilities: Intellectual disabilities*. American Association on Intellectual and Developmental Disabilities.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing.
- Apanasionok, M. M., Hastings, R. P., Grindle, C. F., Watkins, R. C., & Paris, A. (2019). Teaching science skills and knowledge to students with developmental disabilities: A systematic review. *Journal of Research in Science Teaching*, 56(7), 957–984. <https://doi.org/10.1002/tea.21531>
- Bowman, J. A., McDonnell, J., Ryan, J. H., & Fudge-Coleman, O. (2019). Effective mathematics instruction for students with moderate and severe disabilities: A review of the literature. *Focus on Autism and Other Developmental Disabilities*, 34(4), 195–208. <https://doi.org/10.1177/1088357619827932>
- Bowman-Perrott, L., Gilson, C., Boon, R. T., & Ingles, K. E. (2023). Peer-mediated interventions for students with intellectual and developmental disabilities: A systematic review of reviews of social and behavioral outcomes. *Developmental Neurorehabilitation*, 26(2), 134–154. <https://doi.org/10.1080/17518423.2023.2169878>
- Buntinx, W. H. E., & Schalock, R. L. (2010). Models of disability, quality of life, and individualized supports: Implications for professional practice in intellectual disability. *Journal of Policy and Practice in Intellectual Disabilities*, 7(4), 278–294. <https://doi.org/10.1111/j.1741-1130.2010.00278.x>
- Christ, S. E., Stichter, J. P., O'Connor, K. V., Bodner, K., Moffitt, A. J., & Herzog, M. J. (2017). Social skills intervention participation and associated improvements in executive function performance. *Autism Research and Treatment*, 2017, Article 5843851. <https://doi.org/10.1155/2017/5843851>
- Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child Development*, 82(1), 405–432. <https://doi.org/10.1111/j.1467-8624.2010.01564.x>
- Eratay, E. (2020). Effectiveness of the direct instruction method in teaching leisure skills to young individuals with intellectual disabilities. *International Electronic Journal of Elementary Education*, 12(5), 439–451. <https://doi.org/10.26822/iejee.2020562134>
- European Commission. (2002). *Disability: A human rights approach*. <https://ec.europa.eu>
- Global Burden of Disease Collaborative Network. (2022). *Global Burden of Disease Study 2019 (GBD 2019) healthcare access and quality index 1990–2019*. Institute for Health Metrics and Evaluation.
- Haşiloğlu, M. A., Kocaman, S., & Aydın, S. (2011). Tarım okuryazarlığı ve tarım eğitime bir bakış [A view on agricultural literacy and agricultural education]. *Gazi Eğitim Fakültesi Dergisi*, 31(2), 619–629. <https://izlik.org/JA96BF22CT>
- Iancu, S. C., Hoogendoorn, A. W., Zweekhorst, M. B. M., Veltman, D. J., Bunders, J. F. G., & van Balkom, A. J. L. M. (2015). Farm-based interventions for people with mental disorders: A systematic review of literature. *Disability and Rehabilitation*, 37(5), 379–388. <https://doi.org/10.3109/09638288.2014.932441>
- Johnson, A. (2018). *A synthesis and meta-analysis of the effects of token economies on students with intellectual disability and/or autism* (Doctoral dissertation). University of California, Riverside.

- Joy, Y. S., Lee, A.-Y., & Park, S.-A. (2020). A horticultural therapy program focused on succulent cultivation for the vocational rehabilitation training of individuals with intellectual disabilities. *International Journal of Environmental Research and Public Health*, 17(4), Article 1303. <https://doi.org/10.3390/ijerph17041303>
- Khoronzhevyeh, M., Maximova-Mentzoni, T., Gubrium, E., & Muller, A. E. (2022). Participant engagement in supported employment: A systematic scoping review. *Journal of Occupational Rehabilitation*, 32(3), 414–425. <https://doi.org/10.1007/s10926-021-09987-2>
- Knobloch, N. A., & Martin, R. A. (2002). Teacher characteristics explaining the extent of agricultural awareness activities integrated into the elementary curriculum. *Journal of Agricultural Education*, 43(4), 12–23. <https://doi.org/10.5032/jae.2002.04012>
- Matson, J. L., & Boisjoli, J. A. (2009). The token economy for children with intellectual disability and/or autism: A review. *Research in Developmental Disabilities*, 30(2), 240–248. <https://doi.org/10.1016/j.ridd.2008.04.001>
- Maulik, P. K., Mascarenhas, M. N., Mathers, C. D., Dua, T., & Saxena, S. (2011). Prevalence of intellectual disability: A meta-analysis of population-based studies. *Research in Developmental Disabilities*, 32(2), 419–436. <https://doi.org/10.1016/j.ridd.2010.12.018>
- McKenzie, J. A. (2013). Models of intellectual disability: Towards a perspective of (poss)ability. *Journal of Intellectual Disability Research*, 57(4), 370–379. <https://doi.org/10.1111/j.1365-2788.2012.01547.x>
- Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. Jossey-Bass.
- Mirzamani, S., Ashoori, M., & Adib Sereshki, N. (2011). The effect of social and token economy reinforcements on academic achievement of students with intellectual disabilities. *Iranian Journal of Psychiatry*, 6(1), 25–30.
- Nair, R., Chen, M., Dutt, A. S., Hagopian, L., Singh, A., & Du, M. (2022). Significant regional inequalities in the prevalence of intellectual disability and trends from 1990 to 2019: A systematic analysis of GBD 2019. *Epidemiology and Psychiatric Sciences*, 31, Article e91. <https://doi.org/10.1017/S2045796022000701>
- Nikolopoulou, K. (2023, June 22). What is purposive sampling? Definition & examples. *Scribbr*. <https://www.scribbr.com/methodology/purposive-sampling/>
- Norris, W., Spears, L., & Frazee, S. (2025). Agricultural education for all: Importance and ability of agricultural educators to integrate special education competencies into professional practice. *Journal of Agricultural Education*, 66(1), Article 31. <https://doi.org/10.5032/jae.v66i1.2835>
- Özgüç, C. S., & Cavkaytar, A. (2015). Science education for students with intellectual disability: A case study. *Journal of Baltic Science Education*, 14(6), 804–820. <https://doi.org/10.33225/jbse/15.14.804>
- Piaget, J. (2013). *The construction of reality in the child*. Routledge. (Original work published 1954)
- Schalock, R. L., & Luckasson, R. (2015). A systematic approach to subgroup classification in intellectual disability. *Intellectual and Developmental Disabilities*, 53(5), 358–366. <https://doi.org/10.1352/1934-9556-53.5.358>
- Schnepel, S., Krähenmann, H., Sermier Dessemontet, R. *et al.* The mathematical progress of students with an intellectual disability in inclusive classrooms: results of a longitudinal study. *Math Ed Res J* 32, 103–119 (2020). <https://doi.org/10.1007/s13394-019-00295-w>
- Son, H.-J., Kim, D.-S., & Park, S.-A. (2022). Horticultural therapy for improving the work performance and interpersonal relationships of persons with intellectual disabilities. *International Journal of Environmental Research and Public Health*, 19(21), Article 13874. <https://doi.org/10.3390/ijerph192113874>
- Ulugöl, F., & Eratay, E. (2020). Zihin yetersizliği olan bireylere tarım becerilerinin öğretiminde video modellerle öğretim yönteminin etkililiği [The effectiveness of video modeling instruction in teaching agricultural skills to individuals with intellectual disabilities]. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi*, 21(2), 247–272. <https://doi.org/10.21565/ozelegitimdergisi.530053>
- Villanueva, M. G., Taylor, J., Therrien, W., & Hand, B. (2012). Science education for students with special needs. *Studies in Science Education*, 48(2), 187–215. <https://doi.org/10.1080/14703297.2012.737117>
- Wang, Z., Sommerlad, A., Hassiotis, A., Richards, M., & Livingston, G. (2024). Mid-life social participation in people with intellectual disability: The 1958 British birth cohort study. *PLOS ONE*, 19(5), e0302411. <https://doi.org/10.1371/journal.pone.0302411>

Appendices

Appendices 1. Kitchen Workshop Activities

1. Target Behavior

The student will be able to prepare a salad using tomato, cucumber, and pepper by following verbal instructions.

2. Preparation Phase

Materials:

1 tomato, 1 cucumber, 1 pepper, cutting board, plastic knife, bowl, napkin, apron

Environment:

A quiet school kitchen workshop free from distracting stimuli

Student readiness:

Prerequisite skills such as hand washing and safe cutting with a knife are assessed.

3. Explanation of the Goal

“Today we are going to make a salad together. We will use tomato, cucumber, and pepper. We will do each step together. When you do it correctly, I will give you a reward right away.”

4. Modeling (Demonstration)

The entire process is demonstrated step by step. The instructor only models; the student observes.

Modeling Steps

1. I wash my hands.
2. I take the tomato, pepper, and cucumber and wash them.
3. I place the tomato on the cutting board.
4. I carefully chop the tomato.
5. I carefully chop the cucumber.
6. I carefully chop the pepper.
7. I put all the ingredients into the bowl.
8. I cut the lemon in half and squeeze it over the salad.
9. I add salt and olive oil if desired.
10. I mix the salad.
11. I make it ready to serve.

5. Guided Practice (We Do It Together)

Each step is performed together with verbal instruction. The student receives assistance when needed, and immediate verbal reinforcement is given for correct responses.

Step	Teacher Behavior	Student Behavior	Reinforcement
1	“Now we wash our hands.”	Washes hands	Selected appropriate reinforcer
2	“Take the vegetables and wash them.”	Washes the tomato	Selected appropriate reinforcer
3	“Put it on the cutting board and carefully chop.”	Chops the tomato	Selected appropriate reinforcer
4	“Put it on the cutting board and carefully chop.”	Chops the cucumber	Selected appropriate reinforcer
5	“Put it on the cutting board and carefully chop.”	Chops the pepper	Selected appropriate reinforcer
6	“Put everything into the bowl.”	Puts the ingredients in	Selected appropriate reinforcer
7	“Cut the lemon in half and squeeze it into the bowl.”	Cuts and squeezes lemon	Selected appropriate reinforcer

8	“Add oil and salt to the bowl.”	Adds oil and salt	Selected appropriate reinforcer
9	“Mix the ingredients in the bowl.”	Mixes the ingredients	Selected appropriate reinforcer

Physical prompts are provided when necessary and gradually faded.

6. Independent Practice

The student performs the process independently while being observed. Reinforcement is provided.

Step	Student Behavior	Reinforcement
Performs all steps in sequence	Completes successfully	“You are now a salad master! Let’s enjoy eating it together.” (social reinforcer + activity reinforcer)

7. Evaluation

Checklist

Student Name:

Date:

Instructor:

Step	Correct	Incorrect
1. Washes hands	☐	☐
2. Washes vegetables (tomato, cucumber, pepper)	☐	☐
3. Chops the tomato	☐	☐
4. Chops the cucumber	☐	☐
5. Chops the pepper	☐	☐
6. Adds ingredients	☐	☐
7. Squeezes the lemon	☐	☐
8. Adds oil and salt	☐	☐
9. Mixes all ingredients	☐	☐

Total:

Appendices 2. Kitchen Workshop Activities

Activity No.	Activity Title
1	Getting to Know Agriculture
2	Our Soils
3	Let’s Get to Know Plants
4	I Am Not Afraid of Insects
5	Water Is Life
6	Let’s Organize the Garden and Decorate Our Pots

Taner KÜÇÜK, İsmail SATMAZ. Agricultural awareness education for students with mild intellectual disabilities: An activity-based approach

7	Smart Irrigation
8	Selling Fruits and Vegetables
9	Let's Harvest
10	Kitchen Workshop

Received: *April 15, 2026*

Revised: *May 10, 2026*

Accepted: *May 27, 2026*

Cite as: Küçük, T., & Satmaz, İ. (2026). Agricultural awareness education for students with mild intellectual disabilities: An activity-based approach. *Problems of Education in the 21st Century*, 84(3), 445–464. <https://doi.org/10.33225/pec/26.84.445>

Taner Küçük

Provincial Directorate of National Education, Çanakkale, Türkiye.

E-mail: tanerk22.te@gmail.com

ORCID: <https://orcid.org/0000-0001-5437-5025>

İsmail Satmaz

(Corresponding author)

PhD, Assistant Professor, Department of Curriculum and Instruction, Faculty of Education, Çanakkale Onsekiz Mart University, Çanakkale, Türkiye.

E-mail: ismailsatmaz@comu.edu.tr

ORCID: <https://orcid.org/0000-0003-2696-3019>



RESEARCHER IN THE MAKING: DISCIPLINE-SPECIFIC RESEARCH READINESS AND CAREER INTENTIONS

Marianna Lőrincz

Ferenc Rákóczi II Transcarpathian Hungarian University, Ukraine

E-mail: lorinc.marianna@kmf.org.ua

Hanna Tovkanets

Mukachevo State University, Ukraine

E-mail: tovkane2017@gmail.com

Oksana Tovkanets

Uzhhorod National University, Ukraine

E-mail: oksana.tovkanets@uzhnu.edu.ua

Ildikó Greba

Ferenc Rákóczi II Transcarpathian Hungarian University, Ukraine

E-mail: greba.ildiko@kmf.org.ua

Abstract

Fostering students' preparedness to undertake research, especially as a career pursuit, is a strategic priority in higher education, yet given global instability, its development remains precarious. This study examined comparatively Student Research Engagement Readiness (SRER) among Ukrainian humanities and sciences university students, and how it translated into career intentions. A sequential explanatory mixed-methods design was employed with 255 final-year undergraduate and graduate students. Quantitative data were collected using the validated SRER scale and analyzed through independent samples t-tests, chi-square tests, simple linear regression, and mediation modeling. The data were further triangulated with a reflexive thematic analysis of students' accounts of research-related barriers and proposed institutional improvements.

Results revealed discipline-dependent readiness profiles, where humanities students self-reported higher motivation and fewer barriers, while research self-efficacy and behavioral involvement showed stronger cross-disciplinary consistency. A readiness stratification effect was observed, with science students underrepresented in the highest readiness category. SRER was a positive predictor of research career intentions, explaining a sizeable proportion of variance in students' aspirations. Moreover, self-efficacy mediated the link between barriers and career intentions, where fewer difficulties predicted higher self-efficacy, which in turn led to stronger career aspirations. In terms of institutional improvement, qualitative findings underscored the salience of communication, instructional support, incentives, mentoring, and infrastructure. Overall, research career aspirations emerge from the interplay between cognitive resources, disciplinary environments, and institutional affordances. Bolstering students' self-beliefs appears pivotal in pre-empting the detrimental effects of barriers and fostering research career intentions.

Keywords: research career intentions, student research engagement readiness, higher education

Introduction

Promoting students' preparedness and willingness to undertake and apply academic research is envisioned as a cross-national mission of higher education (Healey & Jenkins, 2022).

Student research engagement is ubiquitously implemented as a strategic means for honing higher-order thinking skills, disciplinary expertise, and a professional scholarly persona (Choi et al., 2021; MacDonald et al., 2024). It comes as no surprise, given the impact of research involvement on students' enhanced academic performance, critical reasoning, and sustained career motivation (Crowe & Brakke, 2019; Parker, 2018).

That said, the effectiveness of embedding research within curricula inherently hinges on how ready students feel cognitively, affectively, and practically to participate. Conceptualized as Student Research Engagement Readiness (SRER), this state of preparedness is a combinatorial construct comprising research-related knowledge, motivational orientation, volitional commitment, and affective positioning toward academic activity (Lőrincz & Csernicsko, 2026). Being more than a skill-based quality, SRER may come under the influence of personal, instructional, and institutional factors.

Evidence suggests that many students encounter impediments that may weaken sustained involvement in research, including inadequate methodological training, limited mentoring, restricted access to resources, and diminished perceptions of research as professionally relevant (Adebisi, 2022; Davis et al., 2020). In educational systems undergoing rapid transformations, especially those confounded by war-induced disruptions, such as in Ukraine, the like challenges become markedly pronounced.

In Ukraine, research is a mandatory curriculum component at all degree levels, culminating in yearly term papers and a final thesis. However, simply placing research in the curriculum does not translate into meaningful engagement or research competence gains (Malachowski et al., 2024). Over the recent years, Ukrainian higher education has seen substantial changes spurred by the Bologna process, curricular modernization, and an emphasis on strengthening research capacity. One of the overarching aims of these reforms is to enhance students' participation in academic inquiry. Nevertheless, under conditions of limited funding, displacement, and institutional instability, research opportunities remain fragile. Existing scholarship suggests that Ukrainian students generally display high educational commitment while simultaneously facing institutional and logistical barriers to research participation (Lőrincz & Povidaichyk, 2026). Despite these insights, discipline-specific exploration and theoretically grounded explanatory models remain scarce.

Against this backdrop, the present study foregrounds the SRER framework as its conceptual anchor. Pertinent literature spells out research preparedness as a constellation of research self-efficacy, motivation, behavioral involvement, and perceived barriers (Lőrincz & Csernicsko, 2026). Concomitantly, they constitute the core of SRER, encompassing students' confidence in their research capacity, their motivational orientation toward inquiry, the extent and intensity of participation in research-related activities, and their perceptions of institutional or psychological constraints. Among these, research self-efficacy has been frequently associated with research engagement. Students confident in their ability to design, implement studies, analyze data, and disseminate findings efficiently are more inclined to initiate research, persevere through setbacks, and seek academic opportunities (Miao et al., 2025). Likewise, both intrinsic and extrinsic motivation to engage in and with research also shapes students' cognitive engagement and willingness to invest more time and effort in research endeavors (Maddens, 2023). Behavioral involvement operationalizes the enacted dimension of SRER, reflecting students' actual participation in research-related activities. Conversely, perceived barriers may attenuate research involvement efforts even among otherwise capable and motivated students (Quintero et al., 2025).

Notably, research engagement is disparately distributed across disciplinary milieus. Research in STEM fields, typically laboratory-based, highly structured, and requiring more technical competence, tenably increases methodological anxiety and exposes students to resource bottlenecks. Humanities research, on the contrary, is often more individually driven

and variable in style, instilling interpretative reasoning and scholarly writing (Healey et al., 2023; Toven-Lindsey et al., 2023). Such distinctions may engender differentiated SRER profiles across fields, potentially overshadowing student effort and long-term academic aspirations. Even so, empirical investigation of discipline-specific configurations of SRER remains overlooked.

A concomitant conceptual lens for understanding how research readiness translates into career intentions is provided by Social Cognitive Career Theory (SCCT) (Lent et al., 1994; Lent & Brown, 2019). It postulates that professional maturation is a socially constructed process where agency is exercised through self-beliefs and goals, yet environmental factors can bolster or undermine personal direction. SCCT, thus, underscores the relationship between personal input (self-efficacy, outcome expectations) and contextual affordances (support and obstacles) in eventually shaping professional identity. In the context of the present study, the SRER categories serve as forerunners to career choices in that self-efficacy and motivation (inculcating outcome expectations) are foundational precursors of intentions to take up research as a profession (Duong et al., 2024).

Grounded in SRER and SCCT, the present mixed-methods study examined the relationship between students' readiness to engage in research and their career intentions, and whether SRER varied by academic field. It further explored how perceived barriers and research self-efficacy were linked to students' professional goals. To this end, the following research questions were formulated:

RQ1: Do students in the humanities and sciences differ in research engagement readiness, and to what extent?

RQ2: Are higher levels of SRER associated with stronger research-related career intentions?

RQ3: How are perceived barriers associated with students' intentions to undertake research as a career?

RQ4: What barriers to research engagement do students self-report, and what improvements do they propose?

Research Methodology

Design

To elucidate how students' readiness to undertake research impacted research career intentions among humanities and sciences students in Ukraine, a sequential explanatory mixed methods design was employed (Creswell & Plano Clark, 2023), combining quantitative and qualitative data analysis. The study was grounded in the SRER framework and Social Cognitive Career Theory (Brown & Lent, 2023), where the former enabled the examination of students' research self-efficacy, motivation, involvement, and perceived barriers, while the latter provided a basis for interpreting how these factors may shape career-related intentions. The selection of this design was prompted by the need for quantitative testing of disciplinary differences, predictive associations, and mediation effects, followed by a qualitative phase looking into students' perceptions of confounding factors for research engagement. Thus, the study complemented statistical insights with contextual interpretation of students' research participation and career intentions, enabling triangulation of findings.

Participants

A convenience sample of 255 university students was aggregated mainly from four universities located in western and central Ukraine. For regression-based measurements, it exceeds commonly recommended minimum requirements. Although probability sampling was

not feasible owing to the ongoing instability affecting Ukraine, the sample size was deemed adequate for the planned statistical analyses. To ensure the respondents had relevant academic experience to evaluate research opportunities, only final-year undergraduate and graduate students were invited. Demographically, the cohort included 154 students from the humanities (predominantly English language and literature) and 101 students from quantitatively oriented disciplines (primarily mathematics and information technologies). Therefore, the findings should be interpreted with caution, as the sciences group does not represent the full range of STEM disciplines. The study adhered to ethical research standards by guaranteeing voluntary participation, confidentiality, and anonymity of responses (BERA, 2018).

Instrument

Research engagement was measured utilizing the SRER scale, which has undergone a rigorous validation process (Lőrincz & Csernicsko, 2026). Essentially, it is a flexible multidimensional instrument designed to assess how ready students are to undertake research. The previous validation supported a four-factor structure. Psychometric evaluation of the tool through exploratory (EFA) and confirmatory factor analysis (CFA) confirmed its theoretical and empirical rigor. The final 27-item CFA model showed acceptable fit ($\chi^2(246) = 720, p < .001, \chi^2/df = 2.93, CFI = .902, TLI = .886, RMSEA = .077, 90\% CI [.071, .083]$). The reliability of the tool's four subscales was verified through Cronbach's alpha, yielding coefficients ranging from .83 to .93, proving its high internal consistency.

The SRER encompasses 27 items across four dimensions: (1) Research Self-Efficacy (9 items) – perceived confidence in completing research tasks, (2) Research Motivation (5 items) – interest and value of research for development and career, (3) Barriers to Research Engagement (8 items) – challenges associated with research, such as lack of time, competence, resources, or anxiety, and (4) Research Participation (5 items) – frequency and intensity of participation in research activities. Additionally, research-related career intentions were assessed on a subscale, capturing students' aspirations to pursue research-oriented careers and their perceived value (item 1 – I intend to continue participating in research after graduation; item 2 – I intend to pursue a career that involves conducting research; item 3 – I am likely to further study in a research-related field). Items enquired about students' likelihood of engaging in research after graduation and research-intensive employment. Cronbach's alpha coefficient for the given scale was .89. The original instrument was developed in English, subsequently translated into Ukrainian using a forward-back translation process by two bilingual experts in the fields of English linguistics and mathematics to ensure equivalence.

To complement quantitative insights collected through the SRER, participants were invited to respond to an open-ended question, eliciting their subjective understanding of barriers, institutional shortcomings, and potential solutions.

Data Collection and Analysis

Quantitative data collected via the SRER tool and career intentions subscale were analyzed utilizing SPSS (Version 23). Before the primary analysis commenced, the dataset was screened for univariate normality by calculating skewness and kurtosis values. Because all items fell within the acceptable ranges ± 3 and ± 8 , a decision was made to use parametric tests. In line with RQ 1, independent samples t-tests were run to compare students in the humanities and sciences based on the four SRER dimensions. Next, a chi-square test of independence estimated the association between academic field and categorized readiness levels, with Cramer's V indicating the effect size. To address RQ2, a simple linear regression analysis examined whether SRER predicted research-related career intentions. To explore the psychological

aspects of career choice outlined in RQ3, a mediation analysis was performed using PROCESS macro v4.2 (Model 4) (Hayes, 2022). Perceived barriers were entered as the predictor (X), career intention as the outcome variable (Y), and research self-efficacy as the mediator (M). Bootstrapping with 5000 samples was used to generate 95% percentile confidence intervals.

Qualitative responses were analyzed by two authors following the six-phase reflexive thematic analysis developed by Braun and Clarke (2022). Commencing with a familiarization phase, the responses written in Ukrainian and English were read and re-read to observe recurring patterns of meaning. During the coding phase, labels were assigned by the researchers independently to data pointing to barriers diverting students from research and proposed improvements. To enhance the credibility of coding, the researchers compared the codes, resolving discrepancies through discussion and refinement of the coding scheme. The initial codes were then merged into broader themes, which were subsequently reviewed and defined as five core categories (e.g., information dissemination, instructional support).

Prompted by the study's sequential explanatory mixed methods design, qualitative and quantitative findings were integrated at the interpretation stage, enabling more in-depth explanation of statistical patterns, especially disciplinary divergences, and offered student-centered directions of institutional reform. Consequently, qualitative data enriched the mediation model, showcasing what exerts influence on students' research participation and further involvement after graduation.

Data collection was administered via Google Forms, mainly in the presence of researchers who helped students clarify items to avoid misinterpretation during the 2025-2026 academic year.

Research Results

An independent samples t-test output (Table 1) documents the results of comparison of the four SRER dimensions between students in the humanities and sciences.

Table 1
Descriptive Statistics and Independent Samples T-Tests by Academic Field

Variable	Group	<i>M</i>	<i>SD</i>	<i>SE</i>	Levene <i>F</i>	Levene <i>p</i>	<i>t</i>	<i>df</i>	<i>p</i>
Self-efficacy	Humanities	3.68	0.79	.06	0.10	.75	-1.57	253	.117
	Sciences	3.84	0.81	.08					
Motivation	Humanities	3.71	0.92	.07	6.24	.01	2.10	227.95	.037
	Sciences	3.48	0.76	.08					
Participation	Humanities	3.54	0.84	.07	0.12	.73	-0.19	253	.851
	Sciences	3.56	0.88	.09					
Barriers*	Humanities	3.08	0.88	.07	9.50	.001	6.41	239.25	.0001
	Sciences	2.48	0.62	.06					

Note: Barriers were reverse-coded, i.e., higher scores indicate lower perceived barriers.

The findings revealed significant disciplinary divergences in research motivation and barriers. Specifically, the humanities cohort reported higher levels of research motivation ($M = 3.71$, $SD = 0.92$) than their counterparts in the sciences ($M = 3.48$, $SD = 0.76$), $t(227.95) = 2.1$, $p = .037$ (equal variances not assumed). However, the size of the difference was small (Cohen's $d = .27$). Furthermore, perceived barriers also diverged to a significant extent. Humanities students reported higher reverse-coded barrier scores ($M = 3.08$, $SD = 0.88$) than sciences students (M

$= 2.48$, $SD = 0.62$), $t(239.26) = 6.41$, $p < .001$, with medium-to-large difference (Cohen's $d = .76$). Consequently, the former group perceived fewer obstacles potentially deterring them from research than the group in science-related fields. Contrastingly, differences between the groups in research self-efficacy, $t(253) = -1.57$, $p = .117$, Cohen's $d = -.20$, and research participation, $t(253) = -0.19$, $p = .85$, Cohen's $d = -.02$ did not reach statistical significance. Thus, while the two respondent groups had comparable levels of confidence and participation extent, their understanding of constraints to undertake research and affective aspects varied by discipline.

Next, a Chi-square test of independence was performed to examine preparedness of the student body and evaluate the association between discipline and the four categorized levels of research readiness (Tables 2, 3).

Table 2
Distribution of SRER Levels by Academic Field

Academic Field	Low	Moderate	Good	Excellent
Humanities	4.3	48.8	32.3	14.6
Sciences	5.5	51.6	40.7	2.2
Total	4.7	49.8	35.3	10.2

Overall SRER scores were classified based on the criterion-referenced ranges established in the previous validation study (Lőrincz & Csernicsko, 2026). After reverse-coding of the barriers dimension, the overall score was calculated as the average of the four dimension means. Participants were then grouped into four readiness levels: low = 1.00 - 2.49, moderate = 2.50 - 3.49, good = 3.50 - 4.19, and excellent = 4.20 - 5.00.

Table 3
Chi-Square Test of Association between Academic Field and SRER Level

Test	Value	df	p
Pearson χ^2	10.32	3	.02
Likelihood ratio	12.62	3	.01
Cramer's V	.20	—	.02

As seen, the relationship was statistically significant ($\chi^2(3) = 10.32$, $p = .02$). The effect size (Cramer's $V = .20$) indicated a small to moderate association. Importantly, a noticeable difference was obtained for the "excellent" level of readiness. While 14.6 % of the humanities cohort achieved the excellent level, a mere 2.2 % of science students did so. Even so, both participant groups were heavily concentrated in the moderate readiness category, accounting for 48.8 % of humanities and 51.6 % of sciences students. The findings may suggest that, despite an existing baseline potential for all fields, students in the hard subjects may encounter more barriers preventing them from reaching the highest levels of autonomous research.

A linear regression analysis was conducted to examine whether SRER was associated with participants' intentions to commit themselves to careers in research. For this, the SRER score was adjusted by excluding the item from the original scale related to career intentions to avoid overlap between the predictor and outcome variable.

Table 4
Linear Regression Predicting Career Intentions from SRER

Predictor	M	SD	B	SE	β	<i>t</i>	<i>p</i>	95% CI LL	95% CI UL
Constant	3.48	0.63	.041	.29	—	0.141	.888	-.530	.612
SRER			.993	.082	.606	12.11	< .001	.832	1.155

Model fit: $R = .606$, $R^2 = .367$, Adjusted $R^2 = .364$, $F(1, 253) = 146.67$, $p < .001$.

The analysis yielded a strong positive association between SRER and career intentions ($r = .606$, $p < .001$), indicating that students who felt more ready for research were more inclined to pursue respective careers. A linear regression analysis confirmed that SRER was a significant positive predictor of career intentions ($B = .993$, $SE = .082$, $\beta = .606$, $t(253) = 12.110$, $p < .001$, 95% CI [.832, 1.155]). The model accounted for 36.7% of the variance in career intentions ($R^2 = .367$, $F(1, 253) = 146.67$, $p < .001$).

To explore the relationship between perceptions of barriers and career intentions with self-efficacy as a mediating factor, a mediation analysis was run using the PROCESS macro (Model 4) (Hayes, 2022).

Table 5
Mediation Analysis Predicting Career Intentions

Outcome / Predictor	B	SE	t	p	95% CI LL	95% CI UL	β
Outcome: Self-efficacy							
Constant	3.146	.180	17.443	< .001	2.791	3.501	—
Barriers (reverse-coded)	.196	.058	3.376	< .001	.082	.311	.208
<i>Model fit: R = .208, R² = .043, F(1, 252) = 11.398, p < .001</i>							
Outcome: Career intentions (direct effect + mediator)							
Constant	1.190	.315	3.774	< .001	.569	1.811	—
Barriers (reverse-coded)	.107	.070	1.530	.127	-.031	.245	.089
Self-efficacy	.533	.074	7.187	< .001	.387	.679	.416
<i>Model fit: R = .443, R² = .196, F(2, 251) = 30.613, p < .001</i>							
Total effect model: Career intentions regressed on barriers							
Constant	2.867	.233	12.322	< .001	2.408	3.325	—
Barriers (reverse-coded)	.212	.075	2.822	.005	.064	.359	.175
<i>Model fit: R = .175, R² = .031, F(1, 252) = 7.965, p = .005</i>							
Effect	B / Effect	SE / BootSE	t	p	95% CI LL	95% CI UL	Standardized effect
Total effect (c)	.212	.075	2.822	.005	.064	.359	.175
Direct effect (c')	.107	.070	1.530	.127	-.031	.245	.089
Indirect effect (a × b) via self-efficacy	.105	.041	—	—	.029	.187	.087

Note. Number of bootstrap samples for percentile bootstrap confidence intervals: 5000.

CI= confidence interval; β= standardized coefficient.

As shown in Table 5, lower barrier levels were positively associated with research self-efficacy (Path a: $B = .196$, $SE = .058$, $t = 3.376$, $p < .001$). The data confirmed that students who perceived fewer barriers tended to report higher levels of research self-efficacy. The total effect of barriers on students' intentions to pursue careers in research was also statistically significant ($B = .212$, $SE = .075$, $t(252) = 2.882$, $p = .005$). Hence, fewer obstacles were generally associated with higher research aspirations. When barriers and self-efficacy were entered into the model predicting career intentions, self-efficacy emerged as their positive predictor (Path b: $B = .533$, $SE = .074$, $t(251) = 7.187$, $p < .001$), putting it in line with SCCT that positions confidence as a principal interpreter of career choice. Meanwhile, the inclusion of the self-efficacy category in the model made the direct effect of perceived barriers on career intentions non-significant (path c': $B = .107$, $SE = .07$, $t(251) = 1.53$, $p = .127$). The overall model accounted for approximately 19.6 % of the variance in career intentions, $R^2 = .196$, $F(2, 251) = 30.613$, $p < .001$. Importantly, the indirect effect of reverse-coded barriers on career intentions through self-efficacy was statistically significant, $ab = .105$, $BootSE = .041$, 95% bootstrap CI [.029,

.187]. The standardized indirect effect was .087, 95% bootstrap CI [.024, .155]. Therefore, the mediation analysis supported an indirect association in which fewer perceived barriers led to stronger research-related career aspirations.

Perceived Barriers and Suggested Improvements

To understand student-led proposals for enhancing research engagement, the quantitative analysis was further complemented by a qualitative phase. In all, 183 participants responded to the open-ended question, corresponding to a response rate of 71.8 %. Comments ranged from one to four sentences in length. The provided responses revealed five core themes characterizing a bottom-up direction for institutional reform: (1) information dissemination, (2) instructional support, (3) financial and academic incentives, (4) mentoring support, and (5) infrastructural enhancement.

A prominent theme voiced by participants concerned the insufficient dissemination of information about student research opportunities, including conferences, competitions, and publication possibilities. Many of them appeared unaware of available research-related activities, posing a major barrier to engagement, as illustrated below:

“Inform students about the upcoming research opportunities; also, students need help with publication of research papers.” (S3)

“Inform more online and offline about available competitions and conferences, so that students know what they are and can participate” (S11).

Furthermore, several respondents noted communication gaps, mentioning that students frequently learned about upcoming events incidentally rather than regularly.

Insufficient formal instruction in research skills also emerged as a salient theme, with a number of students calling for mandatory courses in research methods at the BA level, academic writing instruction, and structured guidance through research. Students expressed the need for “formal courses on conducting research” (S50), “more training in different research methods” (S10), and “seminars on academic writing and preparation of academic papers” (S42). Similarly, participants emphasized the need to integrate research components into the curriculum, believing that coursework with embedded research activities could normalize research involvement and reduce stress associated with independent projects.

Featuring prominently among the barriers was the lack of financial and academic incentives. To address it, respondents suggested implementing additional academic credits or grade-based incentives for extra-curricular research, scholarships, small grants, and formal recognition of research achievements, e.g.,

“Providing small grants or scholarships to students who participate in research projects would incentivize them.” (S12)

“Offering the possibility for students to enroll in subjects and exempting them from the necessity to take an exam based on successful research results can be a powerful research motivator.” (S159)

Mentorship was reported as a cross-disciplinary priority. Participants consistently pointed to the need for accessible and supportive supervisors who could guide them through the research process:

e.g., “Pairing students with faculty mentors who actively conduct research could provide guidance and support.” (S72)

“Scientific supervisors should be more closely involved in working with students.” (S28).

Respondents reported mentorship to be essential for building competence and confidence, indicating that insufficient quality supervision was a psychological and organizational barrier to research participation.

Critically, science students articulated the presence of resource bottlenecks, reprising findings of the quantitative analysis that yielded low “excellent” readiness scores. The overriding concern expressed by students was the lack of access to “modern equipment, laboratories, databases, and academic literature” (S44), indispensable for research. Finally, establishing “specialized platforms for exchanging ideas” (S146) signaled the need for fostering a collaborative research culture.

Discussion

This mixed-methods study identified the association between SRER and career intentions, as well as disciplinary hallmarks of readiness to pursue research among students in humanities and sciences in Ukrainian higher education. Anchored in quantitative analysis using the validated SRER tool followed by qualitative reflexive thematic analysis, the study offered empirical and theoretical insights into the cognitive, motivational, and structural factors, forerunning early research commitment. The obtained results extend existing scholarship on research engagement (Healey et al., 2023; Miao et al., 2025), providing context-bound evidence from the Ukrainian higher education system currently grappling with geopolitical pressures, while simultaneously implementing reforms (Lörincz & Komar, 2023).

Concerning RQ1, the findings revealed statistically significant disciplinary differences in research motivation and barriers, as well as comparable levels of self-efficacy and participation in research-related activities, irrespective of the major. As a corollary, students’ affective engagement and construal of constraints were heavily stratified based on the academic field. The higher motivation exhibited by humanities students may be attributable to deeper curricular implementation of writing, especially in the case of English majors, inquiry-based learning, and research projects, in line with “students as researchers” pedagogy (Healey et al., 2023). Contrastingly, despite comparable confidence levels, the sciences cohort reported greater infrastructural impediments, as shown by both quantitative and qualitative data, which naturally require access to laboratories, equipment, or other resources, reiterating concerns raised in previous studies (Adebisi, 2022; Healey et al., 2023).

The chi-square analysis documented a significant association between academic field and SRER levels. Notably, while both groups clustered predominantly within the moderate readiness levels, humanities students were markedly overrepresented in the “excellent” category. The paucity of science students at the highest level of preparedness may also be the corollary of limited research access or competition for resources. As previously noticed, sustained exposure to and involvement with research are essential for advanced engagement levels (Healey et al., 2023; Toven-Lindsey et al., 2023; Lörincz et al., 2025). Unfortunately, in Ukraine, where research opportunities may be sparse outside elite institutions, students in laboratory-intensive fields may experience impediments to cultivating research readiness (UNESCO, 2024).

Regarding RQ2, the findings yielded compelling evidence that research readiness was linked to their plans to pursue careers in research. Specifically, SRER emerged as a positive predictor of career intentions, explaining a substantial proportion of variance in participants’ willingness to commit themselves to research ($R^2 = .37$). The association strength ($\beta = .61$) suggests that readiness for research is more than a background characteristic, but a key determinant of career orientation toward research.

Notably, the mediation analysis (RQ3) provided support for the role of self-efficacy in shaping research career intentions and mediating the relationship between barriers and professional plans, aligning broadly with SCCT (Lent & Brown, 2019). Its findings lent support to the view that self-efficacy is a powerful psychological construct, potentially mediating constraints and career-related decision-making (Gray et al., 2021; Wang et al., 2025). Specifically, fewer perceived barriers were associated with changes in self-efficacy, which in

turn strongly influenced decisions to undertake research professionally. Importantly, once self-efficacy was included in the model, the direct effect of barriers on career intentions became non-significant. Therefore, external obstacles (e.g., resource paucity) may not directly lower aspirations of would-be researchers. For Ukrainian students, beliefs in one's capabilities may act as an important psychological factor: in the case of healthy self-efficacy, students may be more likely to persist in their goals even in the face of deprivation. This result resonates with recent meta-analyses where domain-specific self-efficacy emerged as a stronger predictor of career persistence than academic grades and research persistence (Wang et al., 2025). From a theoretical perspective, it extends SCCT by demonstrating that readiness components, particularly self-efficacy, serve as precursors of research career commitment.

With respect to RQ4, the qualitative data furnished in-depth contextualization of the recurrent quantitative patterns, illuminating the lived experiences underlying students' readiness profiles. The emerging five themes, namely information dissemination, instructional support, financial and academic incentives, mentoring quality, and infrastructural resources, closely mirror systematic barriers to research engagement and were, therefore, anticipated (Malachowski et al., 2024).

First, persistent communication gaps arose between institutions and students, particularly regarding research opportunities, such as conferences, grants, and publication options. A similar situation where fragmented communication undermined student engagement could be observed in the post-pandemic period (Zohrabi & Zwickl, 2023). Second, a heightened need for instruction in research methods and academic writing further corroborated the expediency of early curricular embedding in research preparation (Buffalari et al., 2020). Third, financial and academic incentives were espoused by students as a motivational lever. Analogous scholarship documented benefits associated with research, such as micro-grants, scholarships, increased participation, and persistence (Berlanga & Corti, 2025), while in financially precarious contexts, as in Ukraine, such incentives may disproportionately boost extrinsic motivation. Fourth, expectedly, mentorship quality reappeared as a cross-disciplinary precept determining research engagement, much in line with available publications where supportive supervision and rapport were closely associated with confidence growth, persistence, and academic identity development (Kapranov & Semenov, 2025). Interestingly, Ukrainian students valued relational and affective support and not merely technical guidance. Finally, science students acutely felt infrastructural constraints, documenting material inequities. However, adequate engagement of STEM majors in research hinges on accessibility to laboratory equipment, supplies, and collaborative research platforms.

Based on the obtained findings, several practical implications can be mapped out. Although Ukrainian universities institutionalize research training, predominantly already at an early undergraduate stage, the concerns expressed by the participants point to its inadequacies in terms of instructional opportunities and quality mentorship. Next, contiguous with the call for information dissemination, universities could implement centralized digital platforms to keep students abreast of upcoming research events and opportunities. Also, financial incentives could encourage students to participate in research by increasing access and motivation. Finally, a critical exigency identified within the responses necessitates further investments in research infrastructure, especially in science fields.

Though insightful, the study is not without limitations. While the SRER model proved robust, the confinement of inquiry to the Ukrainian context may have affected generalizability of its findings. Additionally, the cross-sectional design of the study restricts causal inference of its results. Future research could, therefore, adopt a longitudinal design to trace readiness development along academic stages and also to examine how individual readiness depends on institutional variables, such as mentoring models, research intensity, or funding allocations.

Conclusions and implications

The ambit of the study was to determine whether students were genuinely ready to undertake research across discipline-specific pathways and how such readiness may translate into intentions to pursue research careers. By combining SRER with SCCT, along with quantitative and qualitative evidence, the study evinced that student research was not only a product of psychological factors but also of disciplinary and institutional characteristics. The comparison between students in the humanities and sciences fields documented that readiness was experienced differently. Although levels of research self-efficacy and participation were comparable, students diverged in motivation and perceptions of barriers to a noticeable extent, showing that discipline primed students' relation to and construal of research.

Given that SRER substantially predicted career intentions, the findings suggest that students who felt prepared for research were more likely to envisage research as part of their future careers. Promisingly, research self-efficacy was positively associated with research career intentions. Structural obstacles could not directly suppress aspirations to undertake research professionally. Rather, the influence of difficulties operated through respondents' confidence in their research capabilities. Consequently, catering to students' self-efficacy may sustain their resilience and ambition even in the face of crisis. Readiness, therefore, can be viewed as more than an outcome of effective institutional intervention, but a psychological buffer that could mediate the relationship between external conditions and agency.

The qualitative insights further reinforced that curricular embedding per se was insufficient to cultivate research commitment. Students also voiced the need for systematic training, meaningful mentoring, transparent communication, financial incentives, and adequate research infrastructure, picturing an ecosystem where readiness could mature.

Ultimately, the question stands broader than whether students are ready to undertake research, but whether universities have the capacity to nurture that readiness in an equitable and ongoing way. It gains relevance in higher education contexts, where research is formally present in curricula but students' opportunities to develop as researchers hinge on disciplinary resources and institutional support. By considering the role of cognitions, motivation, institutional affordances, and disciplinary culture, this study situates research engagement as a developmental process that must be purposefully supported if higher education is to prepare the next generation of academics.

Declaration of Interest

The authors declare no competing interests.

References

- Adebisi, Y. A. (2022). Undergraduate students' involvement in research: Values, benefits, barriers and recommendations. *Annals of Medicine and Surgery*, 81, Article 104384. <https://doi.org/10.1016/j.amsu.2022.104384>
- British Educational Research Association. (2018). *Ethical guidelines for educational research* (4th ed.). BERA. <https://www.bera.ac.uk/publication/ethical-guidelines-for-educational-research-2018>
- Berlanga, V., & Corti, F. (2025). Impact of scholarships on university academic performance: A comparative analysis of students with and without scholarships. *Frontiers in Education*, 10, Article 1554073. <https://doi.org/10.3389/educ.2025.1554073>
- Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. Sage.
- Brown, S. D., & Lent, R. W. (2023). Social cognitive career theory. In W. B. Walsh, L. Y. Flores, P. J. Hartung, & F. T. L. Leong (Eds.), *Career psychology: Models, concepts, and counseling for meaningful employment* (pp. 37–57). American Psychological Association. <https://doi.org/10.1037/0000339-003>

- Buffalari, D., Fernandes, J. J., Chase, L., Lom, B., McMurray, M. S., Morrison, M. E., & Stavnezer, A. J. (2020). Integrating research into the undergraduate curriculum: 1. Early research experiences and training. *Journal of Undergraduate Neuroscience Education*, 19(1), A52–A63.
- Choi, Y., Bouwma-Gearhart, J., & Ermis, G. (2021). Doctoral students' identity development as scholars in the education sciences: Literature review and implications. *International Journal of Doctoral Studies*, 16, 89–125. <https://doi.org/10.28945/4687>
- Creswell, J. W., & Plano Clark, V. L. (2023). Revisiting mixed methods research designs twenty years later. In C. N. Poth (Ed.), *The Sage handbook of mixed methods research design* (pp. 21–36). Sage. <https://doi.org/10.4135/9781529682663.n6>
- Crowe, M., & Brakke, D. (2019). Assessing undergraduate research experiences: An annotative bibliography. *Scholarship and Practice of Undergraduate Research*, 3(2), 21–30. <https://doi.org/10.18833/spur/3/2/3>
- Davis, S. N., Jones, R. M., Mahatmya, D., & Garner, P. W. (2020). Encouraging or obstructing? Assessing factors that impact faculty engagement in undergraduate research mentoring. *Frontiers in Education*, 5, Article 114. <https://doi.org/10.3389/feduc.2020.00114>
- Duong, C. D., Tran, V. T., & St-Jean, E. (2024). Social cognitive career theory and higher education students' entrepreneurial intention: The role of perceived educational support and perceived entrepreneurial opportunity. *Journal of Entrepreneurship, Management and Innovation*, 20(1), 86–102. <https://doi.org/10.7341/20242015>
- Gray, M., Kim, M., & Lee, S. (2021). Career self-efficacy as a mediator between emotional intelligence and employment planning among US college students. *Canadian Journal of Career Development*, 20(1), 1–9. <https://doi.org/10.53379/cjcd.2021.85>
- Hayes, A. F. (2022). *Counterfactual/potential outcomes “causal mediation analysis” with treatment by mediator interaction using PROCESS* (Technical Report). Canadian Centre for Research Analysis and Methods.
- Healey, M., & Jenkins, A. (2022). Foreword. In H. A. Mieg, E. Ambos, A. Brew, D. Galli, & J. Lehmann (Eds.), *The Cambridge handbook of undergraduate research* (pp. xx–xxv). Cambridge University Press. <https://doi.org/10.1017/9781108869508>
- Healey, M., Healey, R. L., & West, H. (2023). Reflections on disciplinary perspectives on students as partners. *International Journal for Students as Partners*, 7(1), 1–13. <https://doi.org/10.15173/ijasp.v7i1.5444>
- Kapranov, Y., & Semenog, O. (2025). Academic mentorship in higher education: Comparative study of Ukrainian and European models amid crisis and integration. In *Academic culture of a teacher-researcher in the scientific and educational space: Global, European, and national contexts* (pp. 291–358). Baltija Publishing. <https://doi.org/10.30525/978-9934-26-600-3-16>
- Lent, R. W., & Brown, S. D. (2019). Social cognitive career theory at 25: Empirical status of the interest, choice, and performance models. *Journal of Vocational Behavior*, 115, Article 103316. <https://doi.org/10.1016/j.jvb.2019.06.004>
- Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45(1), 79–122. <https://doi.org/10.1006/jvbe.1994.1027>
- Lőrincz, M., & Csernicskó, I. (2026). Are students ready to undertake research? Developing the Student Research Engagement Readiness scale. *Issues in Educational Research*, 36(1), 161–185. <http://www.iier.org.au/iier36/lorincz.pdf>
- Lőrincz, M., & Komar, O. (2023). Weathering the storm: Unraveling the challenges of EFL student teaching in Ukraine. *Novitas-ROYAL (Research on Youth and Language)*, 17(2), 13–33. <https://doi.org/10.5281/zenodo.10015763>
- Lőrincz, M., & Povidaichyk, M. (2026). Maximizing student research engagement: Weighing the impact of institutional support on perceived gains and motivation. *Journal of Teaching and Learning*, 6(20), 101–118. <https://doi.org/10.22329/jtl.v20i1.9479>
- Lőrincz, M. I., Povidaichyk, M. M., & Vrabel, T. T. (2025). Student research in Ukraine: Differential contribution of research activities to competence. *Bulletin of Science and Education*, 8(38), 877–886. [https://doi.org/10.52058/2786-6165-2025-8\(38\)-877-886](https://doi.org/10.52058/2786-6165-2025-8(38)-877-886)
- MacDonald, A. B., Mekolichick, J., Hall, E. E., Picardo, K., & Richards, R. (2024). Scoping review: Literature on undergraduate research and career readiness. *Scholarship and Practice of Undergraduate Research*, 8(1), 3–14. <https://doi.org/10.18833/spur/8/1/2>

- Maddens, L., Depaepe, F., Raes, A., & Elen, J. (2023). Fostering students' motivation towards learning research skills: The role of autonomy, competence and relatedness support. *Instructional Science*, 51(1), 165–199. <https://doi.org/10.1007/s11251-022-09606-4>
- Malachowski, M. R., Ambos, E. L., Karukstis, K. K., Kinzie, J. L., & Osborn, J. M. (Eds.). (2024). *Transforming academic culture and curriculum: Integrating and scaffolding research throughout undergraduate education*. Routledge.
- Miao, H., Guo, R., & Li, M. (2025). The influence of research self-efficacy and learning engagement on Ed.D students' academic achievement. *Frontiers in Psychology*, 16, Article 1562354. <https://doi.org/10.3389/fpsyg.2025.1562354>
- Parker, J. (2018). Undergraduate research, learning gain and equity: The impact of final year research projects. *Higher Education Pedagogies*, 3(1), 145–157. <https://doi.org/10.1080/23752696.2018.1425097>
- Quintero, B., Maldonado-Rengel, R., Morillo-Puente, S., & Burneo-Sánchez, E. (2025). Attitudes toward and perceptions of barriers to research among medical students in the context of an educational and motivational strategy. *BMC Medical Education*, 25(1), Article 635. <https://doi.org/10.1186/s12909-025-07229-0>
- Toven-Lindsey, B., Sparck, E. M., Kistner, K., Ardam, J., & Arnold, W. (2023). Undergraduate research in humanities, arts, and social sciences: Helping students navigate uncertainty and build community through a structured cohort-based program. *Scholarship and Practice of Undergraduate Research*, 7(2), 15–24. <https://doi.org/10.18833/spur/7/2/2>
- UNESCO. (2024). *Analysis of war damage to the Ukrainian science sector and its consequences*. <https://unesdoc.unesco.org/ark:/48223/pf0000388837>
- Wang, Y., Li, D., Li, J., & Bai, S. (2025). Exploring the relationship between self-efficacy, social support, academic anxiety, and academic outcomes: A meta-analysis structural equation modeling approach. *Frontiers in Psychology*, 16, Article 1714845. <https://doi.org/10.3389/fpsyg.2025.1714845>
- Zohrabi Alaei, D., & Zwickl, B. M. (2023). Challenges and outcomes in remote undergraduate research programs during the COVID-19 pandemic. *Physical Review Physics Education Research*, 19(1), Article 010135. <https://doi.org/10.1103/PhysRevPhysEducRes.19.010135>

Received: April 07, 2026

Revised: May 06, 2026

Accepted: June 12, 2026

Cite as: Lőrincz, M., Tovkanets, H., Tovkanets, O., & Greba, I. (2026). Researcher in the making: Discipline-specific research readiness and career intentions. *Problems of Education in the 21st Century*, 84(3), 465–479. <https://doi.org/10.33225/pec/26.84.465>

Marianna Lőrincz (Corresponding author)	DSc, Full Professor, Philology Department, Ferenc Rákóczi II Transcarpathian Hungarian University, Ukraine. E-mail: lorinc.marianna@kmf.org.ua ORCID: http://orcid.org/0000-0002-2206-7113
Hanna Tovkanets	DSc, Full Professor, Department of Theory and Methodology of Primary Education, Mukachevo State University, Ukraine. E-mail: tovkanec2017@gmail.com ORCID: https://orcid.org/0000-0002-6191-9569
Oksana Tovkanets	DSc, Full Professor, Department of General Pedagogy and Pedagogy of Higher Education, Uzhhorod National University, Ukraine. E-mail: oksana.tovkanets@uzhnu.edu.ua ORCID: http://orcid.org/0000-0003-4438-0167
Ildikó Greba	PhD, Department of Pedagogy, Psychology, Primary and Pre-school Education, and Educational Management, Ferenc Rákóczi II Transcarpathian Hungarian University, Ukraine. E-mail: greba.ildiko@kmf.org.ua ORCID: https://orcid.org/0000-0002-0764-0858



EFFECTS OF A SHORT-TERM TEACHER PROFESSIONAL DEVELOPMENT ON PHYSICS LEARNING UNDER SEVERE RESOURCE CONSTRAINTS: CONCEPTUAL AND SYMBOLIC GAINS WITHOUT PROCEDURAL IMPROVEMENT

**Tade-Etienne N. Mbundu, Ruffin-Benoît M. Ngoie,
Jean-Roger M. Bansimba**

Mbanza-Ngungu Higher Pedagogical Institute, DR Congo
E-mail: tmbundu@isp-mbng.ac.cd, rbngoie@isp-mbng.ac.cd,
abansimba@isp-mbng.ac.cd

God'El K. Kinyoka

National Pedagogical University, DR Congo
E-mail: gkinyoka@isp-mbng.ac.cd

Rama M. Bazangika

Mbanza-Ngungu Higher Pedagogical Institute, DR Congo
E-mail: rbazangika@isp-mbng.ac.cd

Billy Nzau Matondo

University of Liège, Belgium,
E-mail: bnmatondo@uliege.be

Abstract

Physics teaching in SubSaharan Africa often remains theoretical because of a lack of teaching materials and limited access to teacher training, and evidence on lowcost, shortterm professional development in such fragile contexts is scarce. This quasiexperimental study was conducted in ten secondary schools in MbanzaNgungu, Democratic Republic of Congo, with five schools assigned to an experimental group and five to a control group. The sample included 248 students and ten physics teachers from those schools. Data collection relied on a validated tenitem test measuring conceptual, procedural and symbolic dimensions of physics learning, complemented by semistructured teacher interviews. The theoretical framework combined three pillars: the use of lowcost didactic materials, situated learning as conceived by Lave and Wenger, and Bandura's concept of teacher selfefficacy. The main results show that students taught by trained teachers significantly outperformed control students on the conceptual dimension (Cohen's $d = 0.49$) and the symbolic dimension ($d = 1.58$), whereas no significant difference was observed in procedural skills. Persistent errors in algebra, unit conversion, and graphical interpretation remained in both groups. Teachers in the experimental group reported higher selfefficacy but their teaching practices changed in variable ways across individuals. An implication of these findings is that even shortterm professional development can improve conceptual and symbolic learning under severe resource constraints, yet procedural fluency likely requires stronger collaboration between physics and mathematics teachers as well as longer or more targeted interventions.

Keywords: *teacher, professional development, didactic materials, physics education, pedagogical transformation, situational learning, student achievement, Sub-Saharan Africa*

Introduction

The teaching and learning of physics at the secondary level face persistent challenges worldwide. Pedagogical, structural, and technological shortcomings hinder both conceptual understanding and student engagement (Onweh & Akpan, 2014). In lowresource contexts, where education budgets are minimal and quality infrastructure is scarce, these difficulties are particularly acute (Global Education Monitoring Report Team, 2023). A further complication arises from the disconnect between curriculum intentions, which are generally oriented toward competency development, and classroom practices, which remain predominantly theoretical and lecturebased (Abrahams et al., 2013).

SubSaharan Africa exemplifies this predicament. Schools in the region contend with a pronounced lack of functioning laboratories, insufficient teaching materials, gaps in teacher initial training, limited proficiency with technological tools, overcrowded classrooms, and deteriorating infrastructure (Bansimba et al., 2026; Bazangika et al., 2025; DarlingHammond et al., 2017; Ogunniyi, 2004). Under such conditions, physics education is often reduced to the transmission of abstract content, whereas the discipline is inherently exploratory and grounded in observable phenomena.

Several recent studies show that teacher professional development can help. Training programs that include new methodologies and digital tools can improve how teachers design their lessons and respond to students' needs (Fazio & Logman, 2024; Guerrero Zambrano et al., 2025). Teacher selfefficacy matters too. When teachers believe they are capable, they adopt new practices more easily, and student outcomes tend to improve (Lin & Luo, 2023). Teachers with strong selfefficacy are more resilient, more autonomous, and more likely to use studentcentered approaches (Azila Gbetteor et al., 2021; Basileo et al., 2024).

Despite this evidence, few studies have examined whether very shortterm professional development programs, lasting only a few days, can produce measurable gains in student achievement in resourceconstrained African contexts. Furthermore, existing research rarely distinguishes between different cognitive dimensions of physics learning, such as conceptual understanding, procedural fluency, and symbolic reasoning. The present study addresses these gaps.

Theoretical Framework

This study is grounded in three interconnected theoretical pillars: the role of didactic materials in science education, the principles of situational learning, and teacher self-efficacy. These concepts guide the design of the professional development program and inform the interpretation of student outcomes across conceptual, procedural, and symbolic dimensions (Bandura, 1997; Brahmia & Olsho, 2023; Redish & Kuo, 2015).

Didactic Materials

Didactic materials include all resources made available to teachers and students to facilitate the teaching and learning of scientific concepts, procedures, and representations (Thingholm, 2015). In physics education, such materials take various forms. Concrete materials include measuring instruments, physical models, and laboratory apparatus. Symbolic materials comprise diagrams, graphs, equations, and visual representations. Digital resources encompass simulation software, interactive platforms, and virtual laboratories.

The pedagogical significance of didactic materials is well documented. When thoughtfully integrated into teaching sequences, they promote conceptual understanding by allowing students to interact with phenomena directly rather than through verbal description alone (McLoughlin et al., 2024). Through problem solving activities and data interpretation, they support the development of procedural skills. They also contribute to reducing learning inequalities by contextualizing abstract knowledge in concrete, accessible formats.

For this study, didactic materials were operationalized through the fabrication of low-cost local resources, including simple circuit boards and recycled generator models. These materials were embedded within situation-based lessons on electric generators and receivers.

Situational Learning

Situational learning, as articulated by Lave and Wenger (1991), conceptualizes learning as a process of active engagement in authentic social practices. Learners construct knowledge not through passive reception but through participation in meaningful activities situated in real world contexts. Jonnaert (2009) extends this view, describing the situational approach as a constructivist model in which learners build understanding through interaction with complex, contextualized situations.

In this framework, a situation refers to a structured set of elements (problems, constraints, resources, and objectives) that anchors knowledge in learners' lived experience. The pedagogical aim is to foster transferability: developing in learners the capacity to mobilize knowledge appropriately across varied contexts. Bansimba et al. (2026) operationalize this idea by embedding learners in adaptive ecological simulations where scientific reasoning emerges from locally relevant environmental dilemmas. In physics education, this implies designing learning experiences in which scientific principles emerge from and return to the phenomena students encounter in their daily lives.

The situational approach aligns with curricular reforms undertaken in the Democratic Republic of Congo since 2018, which promote competency-based teaching and emphasize contextualized teaching rooted in students' experiential worlds (Jonnaert, 2011, 2018). Within this framework, didactic materials are not neutral supports but embedded resources that mediate action, reflection, and knowledge construction.

In the present intervention, situational learning was implemented through authentic problem scenarios. For example, students were asked to diagnose why lamps in a house no longer light up, a task requiring the application of concepts related to electric generators, receivers, and circuit analysis.

Teacher Self-Efficacy

Self-efficacy refers to an individual's belief in their capacity to execute actions required to achieve specific goals (Bandura, 1977, 1997). Within Bandura's social cognitive theory, self-efficacy is distinct from actual competence; it concerns perceived capability rather than demonstrated skill. This perception influences how people think, feel, motivate themselves, and act.

Self-efficacy develops through four principal sources. Mastery experiences (successful completion of tasks) provide the most authentic evidence of capability. Vicarious experiences, or observing similar others succeed, can strengthen observers' beliefs in their own abilities. Social persuasion, in the form of encouragement and positive feedback, can bolster self-efficacy. Physiological and emotional states, such as stress or fatigue, also inform individuals' judgments of their capability.

In educational contexts, teacher self-efficacy has emerged as a critical construct. Teachers with high self-efficacy demonstrate greater resilience in the face of challenges, more persistent effort, and higher levels of teaching innovation (Azila-Gbetteo et al., 2021; Basileo et al., 2024). They are more likely to adopt student centered approaches, including situational and project-based learning, and to persist when implementation proves difficult (Higde et al., 2014; Lekhu, 2016).

For physics teachers in particular, self-efficacy beliefs influence their willingness to engage with abstract concepts, to facilitate laboratory work, and to address student misconceptions (Lin & Luo, 2023). In this study, we assessed teacher self-efficacy through semi-structured interviews two weeks after the training. The interviews focused on teaching competence, transfer of training, resilience, professional identity, and reflective self-evaluation.

Research Aim and Questions

This study examined the effects of a short-term continuous professional development program for physics teachers in the Democratic Republic of Congo. The training focused on two complementary components: the effective use of didactic materials and the implementation of situation-based teaching. The latter, rooted in the work of Lave and Wenger (1991), involved engaging students with authentic problems drawn from their daily experience, an approach shown to foster deeper cognitive engagement and transferable skills (Jonnaert, 2011, 2018).

We assessed the intervention across three cognitive dimensions: conceptual understanding, procedural fluency, and symbolic reasoning. These dimensions capture distinct aspects of physics competence and allow for a nuanced evaluation of where teacher training yields measurable effects.

Specifically, the study addressed the following research questions:

1. Which dimensions of physics learning improve, and which remain unchanged, following a short-term teacher professional development program on didactic materials and situation-based teaching, compared to conventional teaching?
2. How does participation in this professional development program influence physics teachers' self-efficacy and reported classroom practices?
3. What types of errors persist in student responses after the intervention, and what do these errors indicate about the limits of short-term teacher training?

By situating the study in a resource-constrained African context, this research provides evidence on whether short-term, low-cost interventions can meaningfully improve student achievement. The findings have implications for educational policy and practice in similar settings across the continent.

Research Methodology

Design

This study followed a quasiexperimental approach with a nonequivalent control group design. The research was carried out between September and December 2024 in the educational subdivision of MbanzaNgungu I. The study's scope covered ten secondary schools offering a scientific track at the upper secondary level. The theoretical framework, grounded in didactic materials, situational learning, and teacher self-efficacy, informed the design of the intervention and the selection of outcome measures.

Due to administrative constraints imposed by local educational authorities, pre-test data could be collected only in experimental schools. Authorities permitted only one assessment per school to avoid disrupting school schedules. Consequently, the design incorporated

two complementary analytical strategies: a withingroup comparison of pretest and posttest performance in experimental schools, and a between-group comparison of posttest scores only. The convergence of results across both strategies supports the interpretation that observed gains are likely attributable to the intervention.

Five secondary schools were assigned to the experimental group, and five to the control group. Assignment of schools to groups was not random. Instead, allocation was based on two criteria: teacher years of experience (to ensure balance between novice and experienced teachers across groups) and school management type (private versus official schools).

For schools where physics teachers had similar years of experience and the same management type, assignment to experimental or control groups was determined by exhaustive random drawing. This additional step ensured that when no difference in teacher characteristics existed between two schools, chance alone decided group allocation.

This nonrandom assignment is acknowledged as a limitation in the interpretation of findings. However, nonrandomization was deliberately used to avoid a potential bias. If all experienced teachers had been placed in the same group, the intervention's effects could have been confounded with teacher experience. Balancing the groups on years of experience was a methodological safeguard, not a flaw.

Teachers in the experimental group received a threeday training program focused on didactic materials and situationbased teaching. Teachers in the control group continued with conventional teaching practices and received no intervention. All teachers taught the same topic, electric generators and receivers, during the same period under normal classroom conditions. The study included all students and all teachers from the ten authorized schools. No sampling was applied.

Participants

The study was conducted in the educational subdivision of MbanzaNgungu I in the Democratic Republic of Congo. Ten secondary schools offering a scientific track at the upper secondary level participated. Each school had one physics teacher responsible for finalyear science classes. All teachers held a five-year university degree (BAC+5), the legally required qualification to teach physics at the secondary level in the DRC. Teachers without formal qualification were excluded under the terms of authorization granted by local authorities. This exclusion limits generalizability, as unqualified teachers form a substantial portion of the teaching workforce in many Congolese schools.

All ten teachers were male. No qualified female physics teacher was available in the study area. Table 1 presents the institutional profile of the ten surveyed schools, including student enrollment per school and group assignment.

Table 1
Institutional Profile of Surveyed Schools

School Code	Number of Students	Assigned Group
School 1	31	Experimental
School 2	35	Experimental
School 3	48	Experimental
School 4	7	Experimental
School 5	3	Experimental
School 6	16	Control
School 7	28	Control
School 8	17	Control
School 9	49	Control
School 10	14	Control

Table 2 shows teacher distribution by group, years of experience, and prior training. Four teachers had less than five years of experience (two experimental, two control). Four teachers had between five and ten years of experience (two in each group). Two teachers had more than ten years of experience (one in each group). All teachers reported prior participation in at least one capacitybuilding training organized by the provincial education inspection service.

Table 2
Teacher Characteristics by Group

Teacher ID	Group	Years of Experience	Prior Training
T1	Experimental	< 5	Yes
T2	Experimental	< 5	Yes
T3	Experimental	5-10	Yes
T4	Experimental	5-10	Yes
T5	Experimental	> 10	Yes
T6	Control	< 5	Yes
T7	Control	< 5	Yes
T8	Control	5-10	Yes
T9	Control	5-10	Yes
T10	Control	> 10	Yes

The postintervention assessment included 248 students, with 124 in each group. The experimental group had 65 female and 59 male students. The control group had 69 female and 55 male students. The study covered all students and all teachers from the ten authorized schools. No sampling was applied. For experimental schools, pretest scores from the previous academic year were available for a different cohort of 116 students taught by the same teachers before the intervention.

Classroom Observations

Classroom observations were conducted in all ten schools before the intervention. Preintervention observations revealed that physics teaching was predominantly theoretical, didactic materials were rarely used, and situationbased teaching was not implemented.

Postintervention observations focused on the five experimental schools. They confirmed that teachers used the fabricated didactic materials (circuit boards, generator models) and implemented situationbased teaching as introduced in the training. Quantitatively, in four out of five experimental schools, at least one didactic material was used during more than 50% of lesson time, indicating a substantial uptake of the trained strategies. However, the frequency and quality of procedural teaching varied across teachers.

No postintervention observations were conducted in control schools, as the research authorization did not permit additional classroom visits. Preintervention observations confirmed that control teachers used conventional lecturebased methods without didactic materials or situational approaches.

These observations are not the focus of this paper but are mentioned here to confirm implementation fidelity.

Teacher Professional Development Intervention

We put together a team to design and run the training. The team had six people: a psychologist, an educator, someone who designs educational materials, a secondary physics inspector, a didactician, and a physicist who coordinated everything. The training covered two main things. First, how to use didactic materials in teaching sequences. Second, how to teach with situations.

The part on didactic materials dealt with what counts as a teaching resource, how to make materials from local and recycled things, and how to bring those resources into the classroom. The teachers made simple circuit boards and recycled generator models to use in their own lessons.

The part on situationbased teaching introduced authentic problem design. It also showed ways to base teaching on what students already experience, and techniques to encourage students to ask questions rather than just listen to a lecture. The training also covered what makes a good situation, how to exploit a situation pedagogically, and how to assess within a situational approach. We added topics on problembased learning and inquirybased learning.

Training was delivered in a blended format combining two inperson days with remote followup during the third day via mobile phone calls and text messaging, as Internet access was not available to all teachers. Teacher learning was assessed through classroom simulations, peer feedback, and posttraining observations during actual teaching. Remediation was provided through targeted coaching to participants who required additional support.

Content and Structure of Lessons for Control and Experimental Groups

Both groups studied the same physics topic, electric generators and receivers, over three weeks. Each group spent six hours on the topic, two hours per week.

Teachers in the control group kept using their usual ways of teaching. They gave teachercentered lectures. The teacher wrote theoretical content on the blackboard, sometimes asked questions to the class, and gave written exercises from the textbook. Nobody used any didactic materials except the blackboard and chalk. No situationbased teaching or inquiry activities. Assessment was limited to endofchapter written tests that focused on declarative knowledge. The same teacher taught all lessons. There was no external help or coaching.

Teachers in the experimental group did the threeday training first. After that, they structured their lessons around situationbased teaching. Each lesson started with a real problem from the students' daily lives. For example, why do the lamps in a house stop working? The teachers used the didactic materials they had made during the training, simple circuit boards and recycled generator models, so students could touch and test things. Lessons included inquiry activities, group discussions, and problemsolving tasks. Formative assessment was used throughout, not just at the end. The focus was on what students could do, not just on memorized facts. The same teachers taught all lessons, but we supported them with posttraining observations and some coaching when needed.

Table 3 shows the differences between the two groups: time spent on the topic, lesson structure, use of didactic materials, teaching approach, and how assessment was done.

Table 3

Comparison of Educational Contexts for Control and Experimental Groups

Feature	Control Group	Experimental Group
Topic	Electric generators and receivers	Electric generators and receivers
Total Teaching time	6 hours (2 hours/week over 3 weeks)	6 hours (2 hours/week over 3 weeks)
Lesson structure	Teachercentered lectures	Situationbased, inquirydriven
Didactic materials	Blackboard and chalk only	Fabricated circuit boards, recycled generator models, diagrams
Teaching approach	Objectivebased, theoretical	Situationbased, studentcentered
Feature	Control Group	Experimental Group
Topic	Electric generators and receivers	Electric generators and receivers

Assessment Instrument

A standardized test developed by the expert team assessed student learning across three dimensions of physics understanding.

- *Conceptual dimension*: ability to identify and connect fundamental scientific principles and relationships.
- *Procedural dimension*: capacity to apply methods, solve problems, and execute standard procedures.
- *Symbolic dimension*: fluency in interpreting and manipulating scientific representations, including formulas, diagrams, and graphs.

The test contained ten items. Three items targeted conceptual understanding, three targeted procedural skills, and four targeted symbolic reasoning. Items were distributed across Bloom's taxonomy levels from basic understanding (Level 2) to evaluation (Level 6).

Table 4 presents the classification of test items according to dimension, Bloom's taxonomy level, and evaluative purpose.

Table 4
Analytical Grid of Assessment Items

Item	Dimension	Bloom's Taxonomy Level	Evaluative Purpose
Q1	Conceptual	Understand (Level 2)	Assess definitional clarity and categorical logic
Q2	Conceptual	Understand (Level 2)	Evaluate knowledge of generator properties
Q3	Conceptual	Analyze (Level 4)	Test causal reasoning in basic circuit logic
Q4	Procedural	Apply (Level 3)	Assess ability to define and contextualize
Q5	Procedural	Analyze (Level 4)	Evaluate categorization and applied reasoning
Q6	Procedural	Apply (Level 3)	Test symbol interpretation and component identification
Q7	Symbolic	Apply (Level 3)	Assess symbolic manipulation and circuit analysis
Q8	Symbolic	Analyze (Level 4)	Evaluate symbolic modeling and energy analysis
Q9	Symbolic	Apply (Level 3)	Test algebraic manipulation and Ohm's Law application
Q10	Symbolic	Evaluate (Level 6)	Assess procedural logic and symbolic planning

Instrument Validation

The test was preadministered to a sample of students outside the target population to evaluate psychometric properties. Item difficulty and discrimination indices were calculated using Classical Test Theory procedures (Kline, 2005). Items were retained if they met two criteria: a difficulty index between .30 and .80, and a discrimination index of at least .25 (Ding & Beichner, 2009; Ukofia & Essen, 2021).

Item Q10 (Bloom's Level 6, evaluation) showed a discrimination index of .12, below the conventional threshold. The item was retained because it assessed higherorder reasoning not captured by other items. A sensitivity analysis excluding Q10 was conducted. For the symbolic dimension without Q10, the difficulty index was .27, and the discrimination index improved to .42. The main findings remained unchanged when Q10 was excluded.

Reliability was assessed using Cronbach's alpha. The global Cronbach's alpha for the full 10item test was .84, reflecting the combined variance across all items. Lower alpha values for the procedural dimension ($\alpha = .71$) and conceptual dimension ($\alpha = .78$) are expected, given the small number of items in each subscale (three items each). The symbolic dimension (four items) yielded $\alpha = .82$. The moderate correlations among dimensions (consistent with the nature of physics learning, where conceptual understanding supports symbolic manipulation) contribute to the higher global alpha without threatening the distinctiveness of the three dimensions.

Interrater reliability for the openended questions (Q4, Q5, Q8, Q10) was established by having two independent raters score a randomly selected subset of 30 responses. Cohen's kappa was $\kappa = .79$, indicating substantial agreement. Disagreements were resolved through discussion.

A linguistic clarity review was conducted by a language expert and validated by the expert panel to ensure contextual appropriateness for Congolese secondary students.

Data Collection

Posttest data were collected from all 248 students in the ten participating schools. The assessment was administered on the same day across all schools under the supervision of trained observers who ensured consistency in administration conditions. Teachers from both groups were not present during testing. Tests were graded by independent experts and trained personnel unaware of students' group affiliation. Responses were coded, anonymized, and entered into a database for statistical analysis.

For experimental schools, pretest scores from the previous academic year were available for a different cohort of 116 students taught by the same teachers before the intervention.

Teacher SelfEfficacy Assessment

We interviewed the five teachers from the experimental group about two weeks after the training. The interviews were semistructured. We had ten openended questions, grouped into five themes based on Bandura's model: teaching competence, transfer of training, resilience in teaching situations, professional identity, and reflective selfevaluation. The interviews were done in French. We recorded them with each teacher's permission and transcribed everything word for word.

For the analysis, we used thematic analysis as described by Braun and Clarke (2006). That means we went through six steps: we read through the transcripts to get familiar with the data, generated initial codes, looked for themes, reviewed them, defined them clearly, and finally wrote up the report.

Ethical Considerations

The study followed standard ethical protocols for educational research. Permission was granted by the higher educational authorities of the MbanzaNgungu subdivision. School principals provided institutional consent. All participating teachers gave written informed consent. For student participants, passive parental consent was obtained following local norms. Parents were informed of the study and given the opportunity to withdraw their child. All data were anonymized before analysis. Participants are not identifiable in any report or publication.

Data Analysis

All statistical analyses were conducted using SPSS (version 23). Normality of distributions was assessed using the KolmogorovSmirnov test. For betweengroup comparisons of posttest scores, independent samples *t* tests were used when normality assumptions were met. MannWhitney *U* tests were employed as nonparametric alternatives.

Because students were nested within schools and teachers (10 schools, 10 teachers), the assumption of independence of observations was violated. To assess whether the nesting of students within schools affected the results, sensitivity analyses were conducted using robust standard errors clustered at the school level and using schoolmean aggregated scores. These sensitivity analyses confirmed the pattern of statistical significance obtained with the conventional tests (see Results). For simplicity, results from conventional tests (independent samples *t* tests and MannWhitney *U* tests) are presented in the tables.

For withingroup comparisons in experimental schools (pretest cohort, $n = 116$, versus posttest cohort, $n = 124$), independent samples *t* tests were used because the two cohorts comprised different individuals. Effect sizes (Cohen's *d*) were calculated for all comparisons (Cohen, 1988).

Because the school-level data were not normally distributed, heterogeneity between schools was examined using a Kruskal-Wallis test, followed by Dunn's post-hoc test with Bonferroni correction. Results are interpreted conservatively given the small number of schools ($n = 10$).

Research Results

Descriptive Results and Group Comparisons

Table 5 presents itemlevel means and standard deviations for the experimental and control groups on the posttest. Standard deviations are reported separately for each group for each of the ten items.

Table 5
ItemLevel Descriptive Statistics by Group

Dimension	Item	Experimental group			Control group		
		<i>M</i>	<i>SD</i>	Dimension mean	<i>M</i>	<i>SD</i>	Dimension mean
Conceptual	Q1	0.85	0.48	0.77	0.62	0.50	0.63
	Q2	0.92	0.26		0.74	0.40	
	Q3	0.78	0.43		0.55	0.50	
Procedural	Q4	0.68	0.30	0.42	0.60	0.30	0.45
	Q5	0.55	0.26		0.52	0.27	
	Q6	0.48	0.35		0.42	0.50	
Symbolic	Q7	0.52	0.31	0.32	0.28	0.23	0.15
	Q8	0.38	0.27		0.23	0.20	
	Q9	0.31	0.35		0.15	0.20	
	Q10	0.18	0.16		0.08	0.09	

Note. $n = 124$ for both experimental and control groups. SD: Standard deviation.

Normality Testing

Prior to conducting group comparisons, normality was assessed using the KolmogorovSmirnov test. Scores on the conceptual dimension departed significantly from normality in both groups ($p < .001$). Procedural dimension scores also showed nonnormal distributions ($p = .014$ for experimental, $p = .008$ for control). Symbolic dimension scores and total scores were normally distributed in both groups ($p > .05$). Given these results, between-group comparisons were conducted using MannWhitney U tests for conceptual and procedural dimensions, and independent samples t tests for symbolic dimension and total score. For consistency, t test results are also reported with Welch correction where homogeneity of variance assumptions were violated.

BetweenGroup Comparisons

Table 6 presents the results of between-group comparisons. The experimental group significantly outperformed the control group on the conceptual dimension ($U = 9556$, $p = .004$), with a mean difference of 0.14. The effect size for this difference, calculated using Cohen's d from the means and pooled standard deviation, was 0.49, indicating a small to moderate effect.

On the procedural dimension, no significant difference emerged between groups ($U = 6990$, $p = .215$). The control group mean (0.45) slightly exceeded the experimental group mean (0.42), but this difference was not statistically reliable. The effect size ($d = -0.16$) was negligible.

The symbolic dimension revealed the largest group difference. Experimental group students ($M = 0.32$, $SD = 0.12$) substantially outperformed control group students ($M = 0.15$,

$SD = 0.09$), a difference that was highly significant ($t(246) = 12.48, p < .001$). The effect size was large ($d = 1.58$), indicating that the average student in the experimental group scored more than one and a half standard deviations above the average control group student.

Total scores followed a similar pattern. Experimental group students ($M = 0.49, SD = 0.14$) scored significantly higher than control group students ($M = 0.38, SD = 0.12$), with $t(246) = 6.54, p < .001$, and a moderate to large effect size ($d = 0.83$).

Table 6
Between-Group Comparisons of Post-Test Scores

Dimension	Experimental Mean (SD)	Control Mean (SD)	Mean Diff	Test Statistic	p	Cohen's d
Conceptual	0.77 (0.18)	0.63 (0.21)	0.14	$U = 9556$	.004	0.49
Procedural	0.42 (0.15)	0.45 (0.16)	-0.03	$U = 6990$	.215	-0.16
Symbolic	0.32 (0.12)	0.15 (0.09)	0.17	$t = 12.48$	< .001	1.58
Total	0.49 (0.14)	0.38 (0.12)	0.11	$t = 6.54$	< .001	0.83

Note. For symbolic dimension and total score, degrees of freedom = 246. For conceptual and procedural dimensions, U values are reported. SD: Standard deviation.

As shown in Table 7, the pattern of statistical significance remained consistent across all three analytical approaches. The conceptual dimension remained significant (all $p < .05$), the procedural dimension remained nonsignificant (all $p > .05$), and both the symbolic dimension and total score remained significant (all $p < .01$). These results confirm that the main findings are not artifacts of the nested data structure or the choice of analytical method.

Table 7
Sensitivity Analysis: Comparison of pvalues Across Analytical Approaches

Dimension	Conventional test (p)	Robust SE clustered by school (p)	Schoolmean aggregated (p)
Conceptual	.004	.011	.024
Procedural	.215	.308	.412
Symbolic	< .001	< .001	.003
Total	< .001	< .001	.002

Note. Conventional tests: independent samples t -test for symbolic and total scores; MannWhitney U test for conceptual and procedural dimensions (see Table 6). Robust standard errors were clustered at the school level ($n = 10$ schools). Schoolmean aggregated scores were compared using independent samples t -tests ($n = 10$ schools). SE: Standard error.

WithinGroup Comparisons for Experimental Schools

For the five experimental schools, pretest scores from the previous academic year were available for a different cohort of 116 students taught by the same teachers before the intervention. Table 8 presents a comparison between the pretest and the posttest cohorts.

Significant gains appeared across all dimensions. Conceptual understanding increased from 0.52 to 0.77, $t(238) = 10.24, p < .001, d = 1.32$. Procedural skills improved modestly from 0.38 to 0.42, $t(238) = 2.18, p = .030, d = 0.28$. Symbolic reasoning showed substantial improvement from 0.18 to 0.32, $t(238) = 9.76, p < .001, d = 1.26$. Total scores increased from 0.34 to 0.49, $t(238) = 8.85, p < .001, d = 1.14$.

It is important to note that the following withingroup comparisons (pretest vs posttest in experimental schools) show changes over time, not causal effects of the intervention. These results complement the between-group comparisons reported above.

Table 8
Within-Group Comparisons for Experimental Schools: Pre-Test versus Post-Test

Dimension	Pre-Test Mean (SD) (n=116)	Post-Test Mean (SD) (n=124)	Mean Gain	t	df	p	Cohen's d
Conceptual	0.52 (0.20)	0.77 (0.18)	0.25	10.24	238	< .001	1.32
Procedural	0.38 (0.14)	0.42 (0.15)	0.04	2.18	238	.030	0.28
Symbolic	0.18 (0.10)	0.32 (0.12)	0.14	9.76	238	< .001	1.26
Total	0.34 (0.13)	0.49 (0.14)	0.15	8.85	238	< .001	1.14

Note. SD: Standard deviation.

Item Difficulty and Discrimination Indices

Table 9 reports item difficulty and discrimination indices calculated from the full posttest sample ($n = 248$). Difficulty indices ranged from .13 (Q10) to .87 (Q2), indicating that the test captured a broad spectrum of student ability. Discrimination indices exceeded the conventional threshold of .25 for all items except Q10, which showed poor discrimination (.12). This item, corresponding to Bloom's evaluation level, proved challenging for students regardless of overall performance level.

At the dimension level, conceptual items demonstrated appropriate difficulty (.70) and strong discrimination (.59). Procedural items were more difficult (.43) with acceptable discrimination (.28). Symbolic items were the most challenging (.24) but maintained adequate discrimination (.34) when Q10 was included. Excluding Q10 raised the symbolic dimension discrimination to .42.

Table 9
Item Difficulty and Discrimination Indices

Dimensions	Items	Difficulty indices		Discrimination indices	
		Item index	Dimension index	Item index	Dimension index
Conceptual	Q1	.60	.70	.76	.59
	Q2	.87		.36	
	Q3	.65		.66	
Procedural	Q4	.72	.43	.28	.28
	Q5	.29		.26	
	Q6	.29		.31	
Symbolic	Q7	.31	.23	.46	.34
	Q8	.30		.39	
	Q9	.20		.40	
	Q10	.13		.12	

School Level Heterogeneity

Nonparametric analyses were conducted due to violation of normality assumptions. A KruskalWallis test revealed significant differences among the ten schools on all dimensions: conceptual ($H(9) = 72.542, p < .001$), procedural ($H(9) = 60.582, p < .001$), symbolic ($H(9) = 138.608, p < .001$), and total score ($H(9) = 101.456, p < .001$). Post hoc pairwise comparisons

using Dunn's test with Bonferroni correction identified specific patterns of school performance. Lower mean ranks indicate better performance (Figure 2).

On the conceptual dimension, experimental School 2 (Mean Rank = 70.7_b) significantly outperformed all other schools. Experimental Schools 3, 6, 7, and control School 9 (135.0_a) formed an intermediate tier, while control School 8 (216.6_c) performed the worst.

On the procedural dimension, experimental School 5 (42.0_{ade}) and control School 6 (49.2_{be}) achieved the lowest mean ranks, followed closely by control School 7 (73.8_{bde}). Control School 8 again showed the poorest performance (205.5_c).

On the symbolic dimension, the largest performance gap emerged. Experimental Schools 3 (48.1_c) and 2 (80.0_{ae}) outperformed all others, followed by control School 7 (98.0_{abe}). Control School 8 (226.8_c) was weakest, with experimental School 5 also performing poorly (187.5_{abcd}).

For total score, experimental Schools 2 (76.3_b) and 3 (79.8_b) ranked best, together with control Schools 7 (92.7_{bd}) and 6 (105.4_{abe}). Control School 8 (234.9_c) remained the lowest performer.

In summary, experimental schools consistently outperformed control schools on conceptual and symbolic dimensions, with Schools 2 and 3 leading. On procedural skills, one experimental school (School 5) excelled alongside control Schools 6 and 7. Control School 8 was the weakest across all dimensions.

Visual Representation of Student Performance

Figure 1 presents radar charts comparing student competency profiles across the three dimensions. The experimental group's polygon nearly encompasses the control group's polygon, visually confirming superior performance across all dimensions.

Figure 1
Radar Chart of Dimension Performance

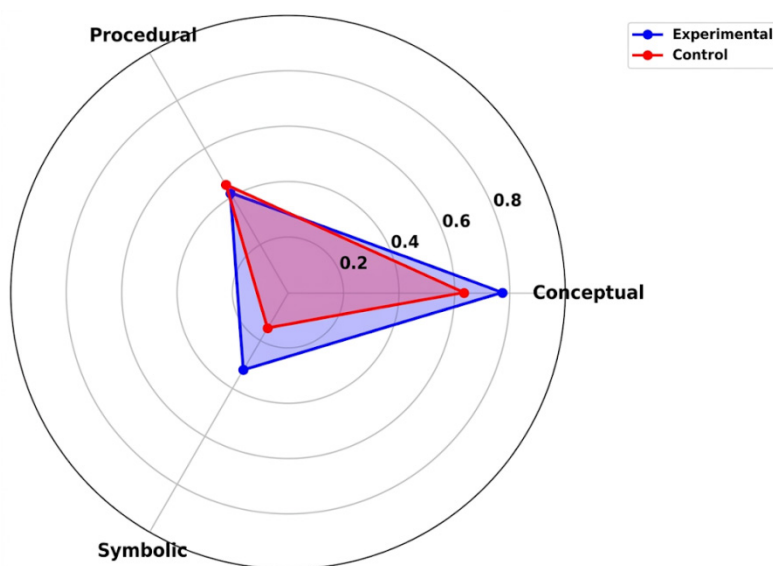
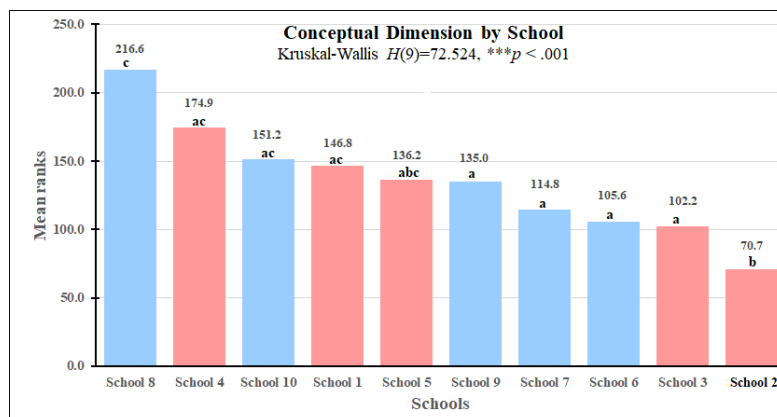


Figure 2 presents schoollevel mean ranks for (a) conceptual, (b) procedural, (c) symbolic, and (d) total score dimensions. Red bars indicate experimental schools, blue bars indicate

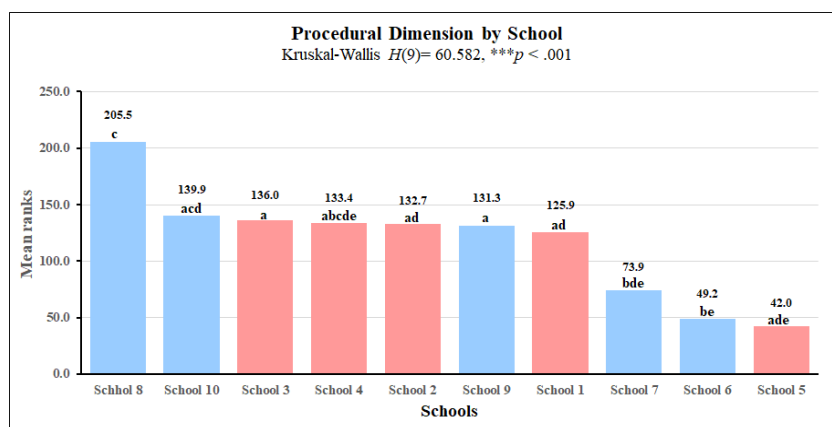
control schools. These plots reveal substantial heterogeneity among schools, particularly in the symbolic dimension.

Figure 2

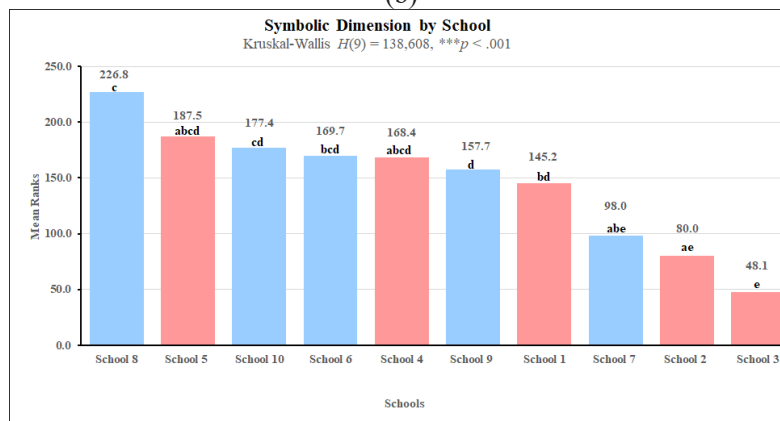
Mean Ranks and Homogeneous Subsets for Conceptual, Procedural, Symbolic, and Total Score Dimensions across 10 Schools (Dunn's Test with Bonferroni Adjustment)



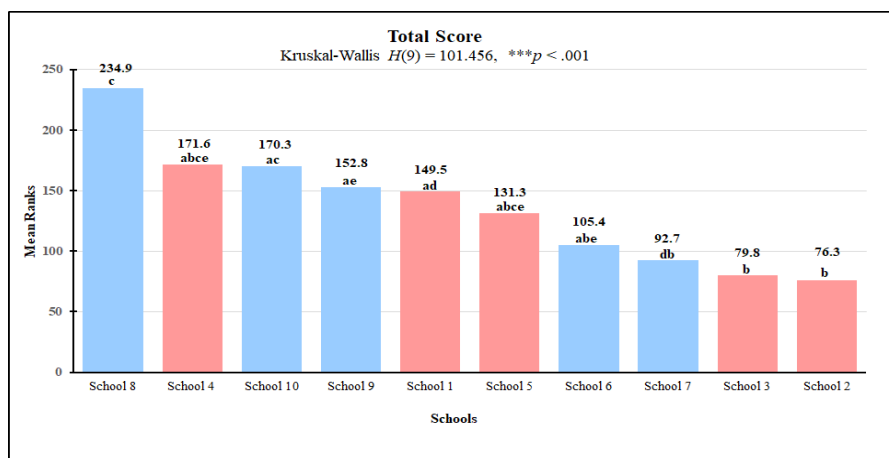
(a)



(b)



(c)



(d)

Note. Values sharing the same subscript letter (a, b, c, d, e) do not differ significantly at $p < .05$ after Bonferroni correction.

Error Analysis

Table 10 summarizes the nature and persistence of errors observed in student responses. Errors fell into three categories: those corrected in the experimental group (present in control but absent or substantially reduced in experimental), those persisting in both groups, and those for which evidence was inconclusive.

Conceptual errors involving confusion between receivers and generators (Q1), misidentification of generator properties (Q2), and misunderstanding of open versus closed circuits (Q3) were prevalent in the control group but largely absent in the experimental group. Similarly, incomplete definitions and examples (Q4) were corrected following the intervention.

Errors that persisted despite the intervention included confusion about energy types and applications (Q5), misreading of symbols and current direction (Q6), ignoring internal resistance in calculations (Q7), misuse of Ohm's law and unit conversion (Q9), illogical problemsolving sequences (Q10a), and omission of essential tools (Q10b). These errors appeared with comparable frequency in both groups.

Item Q8 (misconceptions about EMF, voltage, and efficiency) yielded inconclusive results due to incomplete responses in the experimental group. Many students left this item blank or provided partial answers that could not be reliably coded.

Table 10

Summary of Learner Errors, Their Persistence, and Illustrative Examples

Item	Nature of Error	Illustrative Student Error	Observed in Control	Observed in Experimental	Status
Q1	Receiver vs. generator confusion	Selecting the generator definition for a receiver.	Yes	No	Corrected
Q2	Misidentifying generator properties	Choosing "polarity and internal resistance" instead of EMF.	Yes	No	Corrected
Q3	Open vs. closed circuit confusion	Marking "True" for "if a lamp fails, the circuit must be closed."	Yes	No	Corrected
Q4	Incomplete definition/examples	Vague definition ("It produces current") with a poor example ("A battery").	Yes	No	Corrected
Q5	Confusion on energy types	Listing "electrical energy" as input for a generator.	Yes	Yes	Persistent
Q6	Misreading symbols/current	Selecting a battery symbol to represent a receiver.	Yes	Yes	Persistent
Q7	Ignoring internal resistance	Calculating current using only the external resistor ($I = 10/4 = 2.5 \text{ A}$).	Yes	Yes	Persistent
Q8	EMF/voltage misconceptions	Confusing terminal voltage with EMF to find internal resistance.	Yes	Incomplete	Inconclusive
Q9	Ohm's law/unit conversion errors	Using 238 mA as 238 A in a calculation.	Yes	Yes	Persistent
Q10a	Illogical problem-solving sequence	Suggesting replacing the bulb before checking for power.	Yes	Yes	Persistent
Q10b	Omitting essential tools	Listing a new bulb but forgetting a multimeter for diagnosis.	Yes	Yes	Persistent

Teacher Self-Efficacy: Qualitative Findings

Four patterns emerged from the interviews, though not all teachers expressed the same views.

Teaching confidence. Four teachers said they felt less anxious about teaching topics they previously avoided. One teacher explained: "Before, I would skip some parts. I was not sure how to explain them. Now I try anyway. I prepare more before class." Another teacher added: "I still have trouble with some formulas, but I am not afraid to stand in front and try." A third teacher said: "The training helped me see that I do not need to know everything. I can learn with the students sometimes." One teacher, however, expressed continued hesitation: "I still do not feel confident with the symbolic part. The training gave me ideas, but in class it is different. The students ask questions I did not expect."

Changes in classroom practice. All five teachers reported changing at least one aspect of their teaching. Two teachers said they started using local examples more often. One said: "I asked students to bring old batteries and small bulbs from home. We built simple circuits. They liked it. I will do this again." Another teacher described a change in pacing: "Before, I would answer my own question if no one spoke. Now I wait longer. Sometimes I wait too long, but I am learning." A third teacher tried the situation about lamps that do not light up. He said: "It worked well, but it took more time than I expected. I had to cut some exercises. Next time I will plan better." Two teachers mentioned that not all changes worked. One said: "I tried group work once, but the class became noisy. I went back to lecture. Maybe I will try again later."

Resilience and problemsolving. Three teachers reported feeling better equipped to handle student confusion. One said: “When students do not understand, I do not get angry anymore. I ask another student to explain in their own words. Sometimes it helps. Sometimes it does not.” Another teacher noted: “I still struggle with students who mix up voltage and current. I have tried three different explanations. Nothing works perfectly yet.” A third teacher said: “Before the training, I would just repeat the same sentence louder. Now I try to draw a picture or use an example from the house. It works better.” The two remaining teachers said they still felt frustrated when students did not understand. One of them said: “I know I should be patient, but when the same student makes the same error for the third time, I lose my temper. I am working on it.”

Professional identity. Two teachers explicitly described a shift in how they saw their role. One stated: “I used to think my job was to finish the program. Now I think my job is to make sure they understand. If they do not understand, I have not finished.” Another teacher said: “I am still the boss in the classroom, but I let them talk more. It is a small change, but it is a change.” The other three teachers did not express a clear shift in professional identity. When asked about their role, they focused on techniques rather than identity. One said: “I am a physics teacher. That has not changed. What changed is that I have more materials to use.”

We saw differences between the five teachers. Four felt more confident. One was still unsure. All five changed something in their teaching, but not every change worked well. Three teachers found better ways to help confused students. Two still got frustrated easily. Only two described a clear shift in their professional identity.

The quantitative results showed no improvement in procedural skills. Maybe that is because the teachers lacked good strategies for teaching procedures. They also did not know how to handle unexpected student questions.

Discussion

Interpretation of Main Findings

Conceptual and symbolic gains. Students from the trained teachers scored higher than controls in both conceptual and symbolic dimensions. The effect sizes were moderate to large. In the experimental schools only, we also compared two different cohorts taught by the same teachers before and after the training. Those comparisons showed large gains as well (conceptual $d = 1.32$, symbolic $d = 1.26$). Taken together, these results suggest that even a threeday training can improve student performance in these two areas. We did not expect such a clear difference for symbolic reasoning. The fabricated materials, simple circuit boards, and recycled generator models may have helped. Students could see what the diagrams represented. That tangibility probably matters. Our finding aligns with what McLoughlin et al. (2024) and others have argued: manipulating physical objects supports the interpretation of abstract symbols.

The conceptual gains were less surprising. When teaching starts from authentic problems, students build links between formal knowledge and their daily lives. That is exactly what situated learning predicts (Jonnaert, 2011, 2018). Our training emphasized problems like failing lamps in a house. Teachers who used such scenarios reported that students engaged more than usual.

Procedural skills. Here, the results were different. We found no significant difference between experimental and control students on procedural items ($p = .215$). Within the experimental schools, there was a small gain from pretest to posttest ($d = 0.28$, $p = .030$), but that gain was much smaller than for the other two dimensions. The between-group comparison, which is less sensitive to cohort differences, showed no improvement at all. Our interpretation is that the intervention did not meaningfully change procedural skills.

Procedural skills in physics depend heavily on mathematical fluency: unit conversion, algebra, and graph interpretation. Students in both groups made the same kind of errors on these tasks, even when they clearly understood the underlying physics concepts. This pattern matches what others have found. Badmus and Jita (2024) reported that South African students who struggle in physics usually have weak math skills. Tong et al. (2025) showed that algebra ability predicts physics problemsolving regardless of teaching quality. The errors we saw, misapplying Ohm's law, incorrect unit conversions, and illogical solution sequences, fit exactly with those findings.

Teacher selfefficacy and classroom practice. In the interviews, most trained teachers said they felt more confident. Some changed their routines. A few even talked about their role as a teacher differently. But not everyone changed the same way. One teacher remained hesitant. Two others said they still felt frustrated when students did not understand. Training alone is clearly not enough. A teacher's prior beliefs and years of experience probably shape how much they adopt new strategies. Bandura (1997) would say that people interpret mastery experiences differently, and we saw that variability in our small sample.

Why did procedural skills not improve? The interviews gave us one clue. Several teachers admitted they lacked specific strategies for teaching procedures. They did not know how to respond when students asked unexpected questions about calculations or unit conversions. Even when they felt more confident overall, they had not developed methods for scaffolding procedural learning. This suggests that procedural fluency may require longer interventions or collaboration with mathematics teachers, not just physicsfocused training.

Schoollevel heterogeneity. After the intervention, schools still differed significantly from each other. Two experimental schools, Schools 2 and 3, performed well on all dimensions. One experimental school, School 4, performed below the others. And one control school, School 7, scored high on several dimensions. This variation matters. All teachers in the study, including controls, had attended at least one prior training organized by the provincial education division. Some control teachers may therefore have improved their teaching before our study started. Others may simply be better teachers regardless of training, or they may have stronger students. Our data cannot test these possibilities, but they should be investigated in future research.

Connection to Existing Literature

Other studies have shown that professional development can help teachers in lowresource schools (Babalola & Ojobalo, 2022; Fazio & Logman, 2024). Our study adds that even three days of training can produce measurable gains in conceptual and symbolic learning.

The null effect on procedural skills contributes to a growing body of work on mathematics as a bottleneck. Badmus and Jita (2024) and Tong et al. (2025) both pointed to weak math skills as a key limit to physics learning. Our study shows that this limit persists even when teachers receive training in didactic materials and situationbased teaching. Procedural skills do not improve automatically. This suggests that improving them may require explicit collaboration between physics and mathematics teachers, or interventions that directly target mathematical reasoning within physics problems.

Our interviews also connect to Bandura's (1997) theory. Teachers who successfully tried new strategies reported more confidence. Those who observed peers during training described adopting similar techniques. Yet not all teachers changed in the same way. That variability is exactly what Bandura would expect: individuals interpret similar experiences differently.

Limitations

We need to be honest about what this study cannot claim.

Causal inference. The absence of a pretest for the control group was not our choice. Local authorities allowed only one assessment per school to avoid disrupting schedules. The same constraint forced us to use different cohorts for pretest and posttest comparisons in experimental schools. These are real limitations. We cannot make strong causal claims. That said, two different analytical strategies converged on the same pattern, which makes us more confident that the intervention had some effect. Still, unmeasured differences between schools may contribute to what we observed.

Different cohorts for pretest and posttest. Because we could not test the same students before and after in the experimental schools, the gains we report could reflect differences in cohort ability, changes in the curriculum, or other historical factors. We cannot isolate the intervention as the only cause.

Clustering. Students were nested in ten schools taught by ten teachers. We did not have enough statistical power for multilevel modeling. We used robust standard errors clustered at the school level, but that is only a partial fix.

Item Q10. This item had poor discrimination (.12). We kept it only because it assessed higherorder reasoning (Bloom's Level 6) that no other item captured. When we excluded Q10 from the sensitivity analyses, the main findings did not change. But the item should be revised or replaced in future studies.

Generalizability. Our sample did not include teachers without formal qualifications. In many Congolese schools, such teachers make up a large portion of the workforce. Our findings may not apply to their classrooms.

Combined intervention. The training had two components: didactic materials and situationbased teaching. Our design does not allow us to separate their effects. Possibly one component drove most of the gains while the other contributed little, or they worked together synergistically. We cannot tell.

Conclusions and Implications

We trained five physics teachers in the Democratic Republic of Congo during a threeday program on didactic materials and situationbased teaching. The other five teachers in the study continued with their usual practices. Students taught by the trained teachers scored higher than students in the control group on conceptual questions ($d = 0.49$) and on symbolic reasoning ($d = 1.58$). We cannot yet tell whether the didactic materials or the situationbased teaching made the difference. Procedural skills did not improve. Students in both groups kept making the same mistakes: wrong unit conversions, poor algebra, and difficulty reading graphs. The trained teachers reported more confidence, but not all of them changed their classroom routines in the same way. Shortterm interventions can help in specific areas, but the effect is partial.

Even in resourceconstrained contexts, shortterm training can strengthen conceptual and symbolic learning. Educational authorities need not wait for ideal conditions to start supporting teachers. Locally fabricated didactic materials and situationbased teaching proved effective in making abstract content more accessible. Procedural skills, however, will require changes beyond what shortterm training can offer. The persistence of algebraic and unit conversion errors indicates that mathematical fluency is a critical bottleneck. Collaboration between physics and mathematics teachers, including joint lesson planning, may be necessary to address this challenge. Attention to scientific language also matters. The reduction of lexical errors in the experimental group shows that explicit vocabulary work can improve students' ability to articulate scientific ideas. Language should be treated as a legitimate teaching target in physics classrooms.

For policymakers, the intervention required only three days and used locally fabricated materials, which makes it feasible to scale even in poorly resourced districts. Shortterm, lowcost professional development modules should be integrated into existing inservice training systems. Improving procedural skills will require changes beyond physics teacher training.

Future research needs more robust designs. Randomized assignment and pretests for all groups would strengthen causal inference, provided that local school authorities give their permission. A factorial design would help, but it requires more schools than we had access to. Longitudinal studies following the same students over time would show whether the gains we observed persist or disappear after a few months. We also suspect that mathematical proficiency plays a large role, but we did not measure it directly. Future studies should include such measures to understand how math skills interact with physics teaching. In the Democratic Republic of Congo, the vast majority of schools employ unqualified teachers to deliver physics teaching. Our sample excluded this population. Research specifically targeting unqualified teachers is therefore necessary before concluding that shortterm training generalizes to all teachers.

More broadly, physics education across SubSaharan Africa faces substantial challenges: underqualified teachers, inadequate materials, overcrowded classrooms, and curricula disconnected from students' lives. These systemic issues are not easily resolved. Still, even modest interventions can help. We saw the clearest gains in conceptual and symbolic domains. This suggests that we need longer interventions or collaboration with mathematics teachers. Improvement does not require unlimited resources, but it does require sustained attention to what teachers need to know, how they can teach effectively, and how their beliefs about their own capacity shape classroom practice. Broader systemic reforms are also needed, including better support for mathematics learning alongside physics.

Declaration of Interest

The authors declare no competing interest.

References

- Abrahams, I., Reiss, M. J., & Sharpe, R. M. (2013). The assessment of practical work in school science. *Studies in Science Education*, 49(2), 209–251. <https://doi.org/10.1080/03057267.2013.858496>
- Arcavi, A. (2005). Developing and using symbol sense in mathematics. *For the Learning of Mathematics*, 25(2), 42–47. <https://www.jstor.org/stable/40248497>
- Azila-Gbettor, E. M., Mensah, C., Abiemo, M. K., & Bokor, M. J. (2021). Predicting student engagement from self-efficacy and autonomous motivation: A cross-sectional study. *Cogent Education*, 8(1), 1942638. <https://doi.org/10.1080/2331186X.2021.1942638>
- Babalola, F., & Ojobola, F. (2022). Improving learning of practical physics in sub-Saharan Africa-system issues. *Canadian Journal of Science, Mathematics and Technology Education*, 22(2), 278–300. <https://doi.org/10.1007/s42330-022-00212-7>
- Badmus, O. T., & Jita, L. C. (2024). Physics difficulty and problem-solving: Exploring the role of mathematics and mathematical symbols. *Interdisciplinary Journal of Education Research*, 6, 1–14. <https://doi.org/10.38140/ijer-2024.vol6.08>
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191–215.
- Bandura, A. (1978). Self-efficacy: Toward a unifying theory of behavioral change. *Advances in Behaviour Research and Therapy*, 1(4), 139–161. [https://doi.org/10.1016/0146-6402\(78\)90002-4](https://doi.org/10.1016/0146-6402(78)90002-4)
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.
- Bansimba, J.-R. M., Isumbisho, P. M., Metho, E. N., Kinyoka, G. K., Bazangika, R. M., Matondo, B. N., & Ngoie, R.-B. M. (2026). From Play to Conservation: Leveraging Video Games and Artificial Intelligence for EcoCultural Emancipation in SubSaharan Africa. *WSEAS Transactions on Environment and Development*, 22, 369–388. <https://doi.org/10.37394/232015.2026.22.30>

- Basileo, L. D., Otto, B., Lyons, M., Yamini, N., & Toth, M. D. (2024). The role of self-efficacy, motivation, and perceived support of students' basic psychological needs in academic achievement. *Frontiers in Education*, 9, 1385442. <https://doi.org/10.3389/feduc.2024.1385442>
- Bazangika, R. M., Ngoie, R. B. M., Bansimba, J. R. M., Kinyoka, G. E. K., & Matondo, B. N. (2025). Benchmarking virtual physics labs: A multi-method MCDA evaluation of curriculum compliance and pedagogical efficacy. *Information*, 16(7), 587. <https://doi.org/10.3390/info16070587>
- Brahmia, S. W., & Olsho, A. (2023). Operationalizing and assessing quantitative reasoning in introductory physics. In G. Karagöz Akar, İ. Ö. Zembat, S. Arslan, & P. W. Thompson (Eds.), *Quantitative reasoning in mathematics and science education* (Vol. 21, pp. 315340). Springer. https://doi.org/10.1007/978-3-031-14553-7_12
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute. <https://files.eric.ed.gov/fulltext/ED606743.pdf>
- Ding, L., & Beichner, R. J. (2009). Approaches to data analysis of multiple-choice questions. *Physical Review Special Topics-Physics Education Research*, 5(2), 020103. <https://doi.org/10.1103/PhysRevSTPER.5.020103>
- Fazio, C., & Logman, P. (2024). *Physics education today: Innovative methodologies, tools and evaluation*. Springer.
- Global Education Monitoring Report Team (2023). *Global education monitoring report, 2023: Technology in education: A tool on whose terms?*. UNESCO. <https://doi.org/10.54676/UZQV8501>
- Guerrero-Zambrano, M., Sanchez-Alvarado, L., Valarezo-Chamba, B., & Lamilla-Rubio, E. (2025). Transforming physics teacher training through ChatGPT: A study on usability and impact. *Education Sciences*, 15(7), 887. <https://doi.org/10.3390/educsci15070887>
- Higde, E., Ucar, M. B., & Demir, C. (2014). The investigation of self-efficacy of pre-service science teachers and pre-service physics teachers towards web pedagogical content knowledge regarding internet use habits. *Procedia - Social and Behavioral Sciences*, 116, 3395–3399. <https://doi.org/10.1016/j.sbspro.2014.01.771>
- Jonnaert, P. (2009). *Compétences et socioconstructivisme : un cadre théorique* [Competencies and socioconstructivism: A theoretical framework]. Armando Editore.
- Jonnaert, P. (2011). Sur quels objets évaluer des compétences [On what objects to assess competencies]. *Éducation et formation*, 296, 3143.
- Jonnaert, P. (2018). *L'éducation de base en République Démocratique du Congo* [Basic education in the Democratic Republic of Congo]. Université de l'Orford.
- Kline, T. J. B. (2005). *Psychological testing: A practical approach to design and evaluation*. SAGE Publications.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.
- Lekhu, M. A. (2016). Physical science teachers' self-efficacy beliefs on conducting laboratory experiments. *International Journal of Educational Sciences*, 14(1–2), 102–109. <https://doi.org/10.1080/09751122.2016.11890483>
- Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Ablex Publishing.
- Lin, Q. W., & Luo, Y. Z. (2023). Physics teachers' self-efficacy, innovative teaching and comprehensive teaching approach: Latent Profile Analysis. *Journal of Educational Research and Innovation*, 22, 668–681. <https://doi.org/10.33225/jbse/23.22.668>
- McLoughlin, E., Kaur, T., De Lange, J., Cepic, M., Sokolowska, D., & Grimes, P. (2024). Supporting educational transitions in physics. In C. Fazio & P. Logman (Eds.), *Physics Education today: innovative methodologies, tools and evaluation* (pp. 21–33). Springer. https://doi.org/10.1007/978-3-031-48667-8_2
- Ogunniyi, M. B. (2004). The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for learners: the practice of higher education. *South African Journal of Higher Education*, 18(2), 289–304.
- Onweh, V. E., & Akpan, U. T. (2014). Instructional strategies and students' academic performance in electrical installation in technical colleges in Akwa Ibom state: Instructional skills for structuring appropriate learning experiences for students. *International Journal of Educational Administration and Policy Studies*, 6(5), 80–86. <https://doi.org/10.5897/IJEAPS2014.0347>

Tade-Etienne N. MBUNDU, Ruffin-Benoît M. NGOIE, Jean-Roger M. BANSIMBA, God'El K. KINYOKA, Rama M. BAZANGIKA, Billy Nzau MATONDO. Effects of a short-term teacher professional development on physics learning under severe resource constraints: Conceptual and symbolic gains without procedural improvement

- Redish, E. F., & Kuo, E. (2015). Language of physics, language of math: Disciplinary culture and dynamic epistemology. *Science & Education*, 24(5-6), 561-590.
- Thingholm, H. B. (2015). Teaching and learning materials as content in teacher education. *Journal of the International Society for Teacher Education*, 19(2), 89–105. <https://files.eric.ed.gov/fulltext/EJ1177128.pdf>
- Tong, T., Pi, F., Zheng, S., Zhong, Y., Lin, X., & Wei, Y. (2025). Exploring the effect of mathematics skills on student performance in physics problem-solving: A structural equation modeling analysis. *Research in Science Education*, 55, 489–509. <https://doi.org/10.1007/s11165-024-10201-5>
- Ukofia, I. B. F., & Essen, C. B. (2021). A comparative analysis of item difficulty and discrimination parameters estimation in classical test and item response theories. *The Colloquium*, 9(1), 1–8. <https://www.ajol.info/index.php/colloq/article/view/240506>

Appendix

Appendix A: Post-Training Interview Guide for Assessing Teacher Self-Efficacy

1. Self-Perceived Competence
 - 1.1. After the training, how confident do you feel in applying the new teaching strategies in your physics classes?
 - 1.2. Can you describe a moment when you felt particularly effective in teaching a concept using the new approach?
2. Real-World Transfer
 - 2.1. What changes have you made in your classroom practices since the training?
 - 2.2. Have you encountered any difficulties in implementing what you learned? How did you respond to them?
3. Educational Resilience and Adaptation
 - 3.1. In challenging teaching situations, do you feel better equipped to manage student engagement or misconceptions?
 - 3.2. What resources or support would help you feel even more confident in applying these methods?
4. Professional Self-Image
 - 4.1. Has the training changed the way you see yourself as a physics teacher?
 - 4.2. Do you feel more capable of innovating or adapting your teaching to different student needs?
5. Critical Self-Evaluation
 - 5.1. If you had to evaluate your own growth since the training, what would you highlight?
 - 5.2. What advice would you give to a colleague who is about to follow the same training?

Appendix B: Administered Student Assessment Questions

Question 1: Which of the following best defines an electrical receiver?

- [a]. A device that consumes mechanical energy to operate.
- [b]. A device that converts mechanical energy into electrical energy.
- [c]. A device that facilitates the flow of electric current in a circuit.
- [d]. A device that consumes electrical energy to perform a function.
- [e]. A device that transforms any form of energy into electrical energy.

Question 2: Which pair of characteristics most accurately describes an ideal electrical generator?

- [a]. Polarity and internal resistance.
- [b]. Electromotive force and internal resistance.
- [c]. Electrical energy and electromotive force.
- [d]. Counter-electromotive force and internal resistance.
- [e]. Electromotive force and counter-electromotive force.

Question 3: True or False: If a lamp fails to illuminate in an electric circuit, the circuit must be closed.

- ☐ True.
- ☐ False.

Question 4: Define the concept of an electrical generator and provide one real-world example illustrating its application in daily life.

Question 5: Complete the following table by identifying the type of energy transformed and two practical applications for each component:

Component	Energy Transformed	Applications (2)
Generator		
Receiver		

Question 6: Select the diagram that correctly represents an electrical receiver:

- [a]. Symbol for a generator.
- [b]. Symbol for a capacitor.
- [c]. Symbol for a battery.
- [d]. Symbol for a resistor.
- [e]. Symbol for an open switch.

Question 7: A battery has an electromotive force of 10 V and an internal resistance of . It is connected to a resistor. Calculate:

- [a]. The current flowing through the circuit.
- [b]. The voltage drop across the internal resistance.
- [c]. The voltage drop across the resistor.
- [d]. The terminal voltage of the battery.

Question 8: A generator with an electromotive force of 24 V supplies a circuit with a total resistance of . When the circuit is closed, the terminal voltage drops to 20 V. Determine:

- [a]. The internal resistance of the generator.
- [b]. The efficiency (percentage yield) of the generator.

Question 9: Three receivers (a resistor, a lamp, and a motor) are connected in series. The current in the circuit is 238 mA. The voltage drops across the components are:

- [a]. Resistor: 3.15 V
- [b]. Lamp: 2.37 V
- [c]. Motor: 6.43 V

Calculate the resistance value of the resistor.

Question 10: A student notices that the lamps in his house no longer light up, despite the switches being correctly positioned. During a physics class, he presents the issue to his teacher, who invites the class to propose a solution.

- [a]. Outline the sequential steps required to diagnose and resolve the problem.
- [b]. List the materials and tools necessary for the intervention.

Received: *March 18, 2026*

Revised: *May 16, 2026*

Accepted: *June 18, 2026*

Cite as: Mbundu, T. E. N., Ngoie, R. B., M., Bansimba, J. R. M., Kinyoka, G. K., Bazangika, R. M., & Matondo, B. N. (2026). Effects of a short-term teacher professional development on physics learning under severe resource constraints: Conceptual and symbolic gains without procedural improvement. *Problems of Education in the 21st Century*, 84(3), 480–504. <https://doi.org/10.33225/pec/26.84.480>

Tade-Etienne N. Mbundu (Corresponding author)	Department of Physics, Mbanza-Ngungu Higher Pedagogical Institute (Institut Supérieur Pédagogique de Mbanza-Ngungu), DR Congo. E-mail: tmbundu@isp-mbng.ac.cd
Ruffin-Benoît M. Ngoie	Professor, Department of Mathematics, Mbanza-Ngungu Higher Pedagogical Institute, DR Congo. E-mail: rbngoie@isp-mbng.ac.cd ORCID: https://orcid.org/0000-0001-9348-9105
Jean-Roger M. Bansimba	Department of Biology, Mbanza-Ngungu Higher Pedagogical Institute (Institut Supérieur Pédagogique de Mbanza-Ngungu), DR Congo. E-mail: abansimba@isp-mbng.ac.cd ORCID: https://orcid.org/0000-0002-4150-1851
God'El K. Kinyoka	Department of Physics and Applied Sciences, National Pedagogical University (Université Pédagogique Nationale), DR Congo. E-mail: gkinyoka@isp-mbng.ac.cd ORCID: https://orcid.org/0009-0000-2286-0667
Rama M. Bazangika	Department of Physics, Mbanza-Ngungu Higher Pedagogical Institute (Institut Supérieur Pédagogique de Mbanza-Ngungu), DR Congo. E-mail: rbazangika@isp-mbng.ac.cd ORCID: https://orcid.org/0009-0000-6430-4271
Billy Nzau Matondo	Department of Biology, Ecology and Evolution, Management of Aquatic Resources and Aquaculture Unit (UGERAA), Freshwater and Oceanic Science Unit of Research (FOCUS), University of Liège, Belgium. E-mail: bnmatondo@uliege.be ORCID: https://orcid.org/0000-0002-7098-9972



MAKING PERFORMANCE TEACHABLE: CURRICULAR ALIGNMENT AND MICROTEACHING IN GROUP PIANO TEACHER EDUCATION

Min Xu, Pan Li, Baiyun Zhou, Xuan Yi

Jiangxi Normal University, P. R. China

E-mail: xumin@jxnu.edu.cn, 004937@jxnu.edu.cn,
005845@jxnu.edu.cn, 005856@jxnu.edu.cn

Abstract

Many pre-service music teachers can play a passage before they can explain, model, or teach it to someone else. This exploratory mixed-methods pilot examines that gap in a required group-piano course at a public normal university in mainland China. The course had been redesigned one year earlier, leaving an archive of checkpoint sheets, SMART practice logs, learning diaries, classroom interaction notes, microteaching plans, and end-of-course assessment forms. In Stage 1, two intact second-year cohorts of non-piano-major undergraduates ($n = 20$) worked through either a redesigned syllabus, organised around a Learning Outcomes-Activities-Evidence matrix and a weekly Listen-Read-Play-Teach cycle, or a conventional demonstration-and-practice routine. Stage 1 is reported descriptively because the archive did not retain medians, interquartile ranges, Mann-Whitney U values, or individual-level distributions, and the per-group sample was too small for responsible inference. Stage 2 re-read process materials from a wider explanatory sample ($n = 40$), using a codebook focused on listening, reading, playing, peer teaching, and difficulty turning performance knowledge into teachable language. The redesigned class cleared more threshold-approved checkpoint tasks, kept more target-linked practice logs, and wrote microteaching plans that named cues, broke demonstrations into steps, and anticipated likely beginner errors. The comparison class more often recognised problems but stopped before teachable explanation. The study offers a modest example of how visible criteria, recurring teach-back, and a revisitable evidence trail can help make practical performance knowledge more teachable.

Keywords: curricular alignment, microteaching, mixed-methods pilot, music teacher education, pre-service teachers

Introduction

Skill-based teacher education often treats competent performance as a bridge to competent teaching. The bridge is not automatic. Pre-service teachers may perform a routine fluently and still struggle to explain why it works, model it for a beginner, or anticipate the first mistake another learner is likely to make (Darling-Hammond, 2006; Dragnić-Cindrić & Anderson, 2025).

This difficulty is not unique to music. Laboratory courses, studio work, physical education, and other practice-heavy routes also ask candidates to convert action into instruction. Recent teacher-education studies suggest that this conversion is stronger when assignments require candidates to use professional knowledge in teaching activity, not only to describe that knowledge in written coursework (Carss et al., 2023; Crawford et al., 2023; Jones & Clarke, 2025; Pale et al., 2023; Spooner-Lane et al., 2023; Trent, 2023). Pale et al. (2023) show early-years candidates connecting academic knowledge with classroom action when course tasks made that connection necessary. Carss et al. (2023) report a related effect when assessment tasks were sequenced across a programme. Studies of emotional preparedness, digital literacy,

critical thinking, and inclusive-schooling readiness point to the same practical condition: the capability has to be visible while candidates still have time to rehearse it (Brígido Mero et al., 2024; Demir Evcimen et al., 2025; Durante, 2025; Protacio, 2025; Vančíková et al., 2025).

Group piano is a useful place to examine this question. The course typically serves non-piano-major undergraduates who will later need keyboard skills for accompaniment, classroom demonstration, and rehearsal support in school music settings (Blackwell & Matherne, 2024; Kong, 2025; Shaw, 2024; Young, 2013).

Keyboard fluency alone does not prepare a student to explain touch, sequence practice for a peer, or diagnose a repeated mistake. For that reason, recent music teacher-education scholarship has pushed against the older assumption that pedagogical knowledge can be left for a later methods course (Tucker et al., 2025; Weidner et al., 2025). The Chinese setting makes this problem sharper. Student-centred reform and formative-assessment discourse have entered school music education, but teacher authority, demonstration-led traditions, and large classes remain familiar classroom conditions (Zhang & Leung, 2023, 2025; Zhang et al., 2025; Zhang et al., 2026). For pre-service music teachers in this context, performance anxiety and teaching anxiety may also interact, making the move from doing to teaching still harder (Cui et al., 2024).

In such a setting, that move rarely happens by accident; it has to be designed for.

Alignment and Visible Criteria in Practical Courses

Constructive alignment and backward design begin from a practical premise: name the outcomes, organise teaching around them, and gather evidence that students have reached them (Biggs, 1996; Biggs & Tang, 2011; Harden, 2007). In teacher education, the value of that premise lies less in tidy syllabus design than in what it makes visible during learning. Carss et al. (2023) show how linked assessment tasks can support candidates' engagement with teaching as inquiry, while Crawford et al. (2023) argue that experiential assessment places pre-service teachers in more authentic evaluative situations. Kerimoğlu and Altun (2024) add that backward design matters most when it changes what candidates can see and do across a course, not only how the course is described on paper.

Practical courses especially need visible criteria. When the standard remains only in the instructor's judgement, students may know that something is wrong without knowing what failed or what to try next. Sadler's (1989) point remains useful here: formative assessment works only when learners understand quality, compare their current attempt with that standard, and act on the difference. Hattie and Timperley (2007), and later Brooks et al. (2019), frame the same problem through feedback questions about direction, current performance, and next steps. Brookhart (2024) extends the argument to teachers' own assessment knowledge, treating it as contextual and action-oriented.

Alignment is used here in that limited sense. Newby and Cornelissen (2025) warn that constructive alignment can become reductive when treated as a universal logic, and that warning is relevant to practical teacher education. The present study uses alignment more narrowly: as a tool for connecting five course outcomes with weekly tasks and with evidence students and the instructor could revisit.

Pedagogical Transformation in Practical Teacher Education

Shulman (1986) treated teaching as a problem of transformation. Knowing subject matter is not enough; the teacher must turn it into explanations, demonstrations, analogies, and judgements that another learner can use. Later work on theory-praxis relations, teaching performance assessment, and school-based judgements of teaching ability reaches a similar point from different directions (Chen & Tu, 2025; Pale et al., 2023; Spooner-Lane et al., 2023).

Music teacher education makes the problem sharper. Musical understanding often sits in the hand and ear before it is available as language. A student may feel the right touch for a phrase, yet still be unable to name the principle, plan the teaching sequence, or predict a beginner's likely mistake (Kong, 2025; Shaw, 2024).

In this study, pedagogical explanation and demonstration refers to four linked moves: explaining why a passage is played in a particular way, modelling that way for another learner, diagnosing likely errors, and adapting the explanation so a peer can act on it. The construct is close to current music teacher-education accounts of pedagogical knowledge, but it is not the same as carrying a performance technique from one piece to another.

Microteaching, Peer Feedback, and Self-Regulated Learning

Microteaching was deliberately brief in this course. A typical slot lasted no more than five minutes and sat inside the weekly lesson, rather than appearing as a separate assessment event. That placement matters. A recent review confirms that microteaching remains a common and useful way for pre-service teachers to rehearse pedagogy before practicum demands increase (Iliasova et al., 2025). The literature also warns against treating it as automatically educative. Trent (2023) shows that candidates may experience microteaching as emotionally demanding when instructor support is weak; Gunawardena (2023) shows that reflective structures can shift the activity away from display and toward reciprocity.

Feedback raises the same issue from another side. Peer comments improve pedagogical judgement only when students know the criteria, trust the exchange, and have strategies for responding to what they hear (Cano García, 2024; Cavanagh & Tran, 2025; Franke et al., 2024; Okumu et al., 2024). Self-regulated learning studies make a comparable demand: learners need visible standards, occasions to monitor their work, and a next action that is concrete enough to try (Nicol & Macfarlane-Dick, 2006; Panadero, 2017). In music education, feedback has often remained teacher-led and task-centred. Recent studies by Blackwell et al. (2023), Blackwell and Matherne (2024), and McPherson and Blackwell (2025) show, however, that structured practice in giving and receiving feedback can help pre-service music teachers build judgements they can use in later teaching.

Teach-back routines therefore serve a design function in practical courses. They require students to put tacit knowledge into words, test whether another learner can act on those words, and then revise both the playing and the explanation.

Research Aim and Questions

Group piano is treated here as a teacher-education problem, not only as a course-reform problem. The study reports a two-stage exploratory mixed-methods pilot of an aligned group-piano design for non-piano-major pre-service music teachers in mainland China. Three questions guided the analysis.

RQ1. In an exploratory intact-class comparison, what descriptive pattern of checkpoint attainment, reported practice time, and end-of-course outcomes is associated with the aligned design relative to a conventional condition?

RQ2. How was pedagogical explanation and demonstration evidenced in day-to-day course work within the aligned design?

RQ3. Which features of the aligned design appear to support the move from performance toward pedagogical explanation and demonstration?

Research Methodology

Design

The materials analysed here came from a redesign of a required group-piano course at a public normal university in mainland China. The redesign had taken place one academic year before the present study. After reviewing the archive, we organised the analysis as a two-stage exploratory mixed-methods pilot. Stage 1 compared two intact classes under ordinary teaching conditions, looking for classroom-level patterns that distinguished the aligned design from a conventional approach. Stage 2 extended the sample within the same course sequence and re-read process materials – learning logs, interaction records, and microteaching plans – to clarify how pedagogical explanation and demonstration developed.

The two stages had different roles. Stage 1 located a pattern in a very small classroom sample, while Stage 2 carried the explanatory work. Random redistribution across classes was not possible because departmental timetabling and intact cohort assignments had already been fixed. The archive therefore offered a practical basis for linking classroom outcomes to learning processes, but not a basis for treating the redesign as a causal experiment.

Context and Participants

The course was a required group-piano class for second-year undergraduates in a music teacher-education programme. All participants were non-piano majors studying keyboard skills for accompaniment, classroom demonstration, rehearsal support, and school-based music teaching. The archived project records show that students with extensive prior piano study had been excluded from the analytic sample; the exclusion threshold was more than ten years of formal training or a Grade-10 piano examination background. Because the analysis relied on archived course records, participant descriptions are limited to variables preserved across both stages: year level, programme status, non-piano-major status, and the prior-piano screening criteria. Age and gender distributions were not preserved in the archived analytic files.

Stage 1 included 20 students drawn from two intact classes (aligned group $n = 10$; comparison group $n = 10$). Stage 2 included 40 students (aligned group $n = 20$; comparison group $n = 20$), comprising the Stage 1 students plus additional students from parallel classes in the same year level and course sequence. The parallel classes followed the same course sequence, entry criteria, assignment requirements, assessment regime, checkpoint thresholds, repertoire bank, and semester schedule. That uniformity supports their use as an explanatory extension rather than as a separate cohort.

The course ran across two semesters for a total of 32 class hours, with one scheduled class period per week. Across both stages, the same course instructor taught all sections, the same repertoire bank and comparable repertoire difficulty were used, and overall time allocation plus core technical content were held constant. This arrangement reduced between-section variability, although course-instructor effects cannot be fully separated from design effects.

Table 1

Archived Baseline Diagnostic Procedures and Comparability Summary

Baseline Domain	Assessment Approach	Archived Between-Group Result
Touch and Tone Control	Diagnostic task rated by four independent raters using a four-level rubric	Archived comparability records indicated no baseline imbalance; full group descriptive statistics were not preserved.
Rhythmic Stability	Diagnostic task rated by four independent raters using a four-level rubric	Archived comparability records indicated no baseline imbalance; full group descriptive statistics were not preserved.
Sight Reading	Diagnostic task rated by four independent raters using a four-level rubric	Archived comparability records indicated no baseline imbalance; full group descriptive statistics were not preserved.

Note. The archived records preserved each diagnostic procedure and a general comparability judgement, but not the underlying group descriptive statistics. The baseline stage is used only to describe initial classroom comparability and not to support inferential claims.

Course Design and Comparison Condition

The comparison condition followed a familiar group-piano pattern: teacher demonstration, student imitation, after-class practice, periodic repertoire checks, with assessment focused on end products. Students received feedback, but process records were sparse and the link between weekly tasks and final outcomes remained largely implicit.

The aligned condition used a deliberately structured design. Five learning outcomes were specified in advance: touch and tone control; rhythmic stability and ensemble coordination; sight reading and self-monitoring; style and musical expression; and pedagogical explanation and demonstration. A Learning Outcomes-Activities-Evidence matrix linked weekly tasks, evidence sources, and attainment thresholds for each outcome.

The aligned lessons used the Listen-Read-Play-Teach sequence each week. First, students listened to modelled contrasts. They then read scores and short technique or expression scripts before moving into segmented rehearsal and peer review. The final step was a brief microteaching task in which a student taught a short excerpt or strategy to classmates. Weekly task sheets kept the criteria visible, while logs, checkpoint records, peer comments, and microteaching plans left a recurring process record across the semester. In practice, the sequence moved from goal prompt to modelled listening, from script preparation to rehearsal, and from peer teaching to evidence-based feedback. The comparison group worked with similar repertoire difficulty and comparable overall time on task. What differed was the explicit linkage among outcomes, weekly tasks, and evidence. Figure 1 summarises the overall study design and the aligned learning cycle.

Table 2
Two-Stage Study Design and Data Sources

Stage	Sample	Purpose	Main Sources	Analysis
Stage 1: Exploratory Classroom Comparison	20 students (10 aligned, 10 comparison)	To identify directional classroom-pattern differences between an aligned design and a conventional group-piano approach	Baseline diagnostics; classroom checkpoint records; weekly practice logs; end-of-course assessment	Descriptive comparison only (means and SDs); no inferential testing
Stage 2: Process Analysis	40 students (20 aligned, 20 comparison)	To explain how pedagogical explanation and demonstration developed in practice	Learning logs; classroom interaction texts; microteaching plans	Theory-informed coding; node comparison; per- student averages; illustrative excerpts

Note. Stage 2 included the Stage 1 participants plus additional students from parallel classes in the same course sequence. Integration occurred at interpretation, with Stage 2 used to explain the patterns observed in Stage 1.

Figure 1
Two-stage study design and aligned learning cycle.

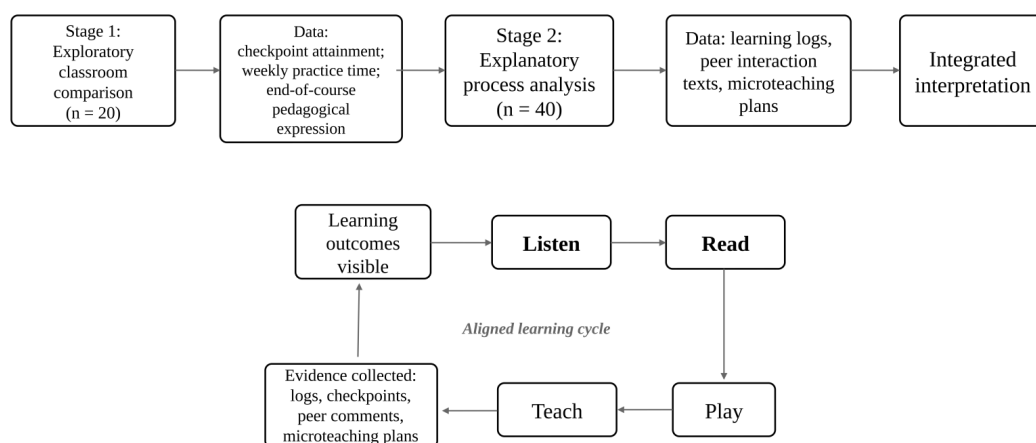


Table 3
Condensed LO-A-E Matrix for the Aligned Group-Piano Design

Learning Outcome	Key Activities	Evidence	Attainment Threshold
LO1. Touch and Tone Control	Contrastive listening; technique script cards; slow, segmented, and synthesis practice	Rubric ratings; 32-bar error sheet	Rubric average of at least 3 on a 4-point scale and error rate no higher than 5%
LO2. Rhythmic Stability and Ensemble Coordination	Rhythmic cueing; duet rehearsal by part; peer review	Collaboration rating; one-pass record	Collaboration score of at least 80/100 and one-pass rate of at least 90%
LO3. Sight Reading and Self-Monitoring	Score-reading prompts; SMART practice logs; self- and peer feedback	Sight-reading error record; weekly logs	Error rate no higher than 5%; at least five sessions and 180 minutes per week
LO4. Style and Musical Expression	Style listening; verbal explanation; expressive script cards	Performance rubric; style quiz	Rubric average of at least 3 on a 4-point scale and quiz score of at least 80/100
LO5. Pedagogical Explanation and Demonstration	Microteaching; decomposed modelling; peer teaching	Microteaching rubric; lesson plan; peer comments	Microteaching score of at least 80/100 and application pass rate of at least 85%

Note. In the archived materials, the fifth dimension was originally labelled teaching expression; the more explicit term pedagogical explanation and demonstration is used here. The microteaching rubric focused on alignment of goals and tasks, demonstration and decomposition, correction and feedback, teaching language and organisation, and transfer-task design.

Data Sources and Measures

Stage 1 used four archived sources. Baseline diagnostics covered touch and tone control, rhythmic stability, and sight reading; four independent raters scored each diagnostic task. The touch-and-tone rubric considered action stability, touch control, tone and dynamic layering, and accuracy. Rhythmic stability and ensemble work were judged through beat stability, entry handling, real-time adjustment, rehearsal engagement, and collaboration. Sight-reading records preserved note errors, rhythm errors, and completion time.

Classroom checkpoint records formed the second source. These records showed how many checkpoint tasks each student completed and passed during the two-semester course. A task counted only when three conditions were met: the student completed an item from the shared course bank, met the threshold for that checkpoint, and received teacher confirmation. Different excerpts from the same piece were not counted separately. The checkpoint totals should therefore be read as cumulative threshold-approved tasks from a shared instructional bank, rather than as counts of full-length pieces. The third source was the weekly SMART practice log, which summarised daily practice time. In the aligned group, students had to enter a target, an indicator, and a method before recording minutes. The fourth source was the performance-based end-of-course assessment. It judged tone control, rhythmic stability, performance presentation, and pedagogical explanation and demonstration; the final dimension required students to explain and model key musical points, not merely perform them. The archived records reported an interrater reliability coefficient of $ICC = .86$ for that assessment.

Stage 2 turned to the process archive: learning logs, classroom interaction texts, and microteaching plans. The logs recorded weekly practice content, difficulty points, strategies, and self-feedback. Interaction texts preserved teacher questions, peer discussion, and immediate

feedback notes. Microteaching plans showed how students organised a short teaching sequence around objectives, demonstration steps, common errors, and corrective cues. The original project did not use video. As a result, plans, observation notes, and rating sheets became the main record of microteaching. These materials capture documented pedagogical planning and explanation more directly than the full quality of live demonstration in interaction. The microteaching rubric asked raters to look for four features in each plan. Goals and tasks had to align. Demonstrations had to break the difficulty into manageable parts. Feedback needed to be actionable and verifiable through a second attempt. The transfer task had to be usable beyond the immediate exercise. Coding units were complete meaning-bearing sentences or standalone lesson-plan items. Generic comments such as “I did not practise well today” were excluded unless they also included a specific error analysis, strategy, explanation, or feedback move. The original qualitative materials were written in Chinese; the authors translated the excerpts into English and checked them against the source wording during drafting.

Coding paid particular attention to pedagogical specificity. A statement such as “practise the left hand more” was not coded as a pedagogical explanation because it named effort without naming a cue, target, error, or teaching move. By contrast, a statement that identified the likely source of instability, proposed a decomposed step, or indicated how a peer would verify improvement was treated as evidence of explanation that could be used in teaching. The distinction kept routine self-report language from being overread as pedagogical development.

Data Analysis

Stage 1 is reported descriptively only. The archived summary files preserved group means and standard deviations, along with attainment counts on the end-of-course rubric. They did not preserve the underlying Mann-Whitney U values, medians, interquartile ranges, or individual-level distributions. Those values cannot be responsibly reconstructed from what remains. Given the n of ten per group, the missing distributional information, and the intact-class design under one course instructor, inferential testing would not be appropriate. Continuous indicators are therefore reported as means and standard deviations, and end-of-course outcomes as attainment counts. Z statistics, p values, and effect-size estimates from earlier outcome tables have been removed. The numerical findings function as classroom-level indicators that motivate the explanatory work in Stage 2, not as treatment-effect estimates.

The qualitative analysis moved between pre-set categories and new patterns in the archive. The first version of the codebook came from the aligned task chain: listening as input, reading as scripted retention, playing as output, and teaching as peer explanation. A further node was added for difficulty translating embodied performance knowledge into teachable language. About one fifth of the materials were double-coded. When coders disagreed, the discussion returned to the code definitions, and the node boundaries were revised before coding the full dataset. The archived project notes reported Cohen’s $\kappa = .83$.

Triangulation was built into the analysis rather than added after coding. We compared logs with interaction texts and plans, checked coder agreement on the shared subset, and integrated the two phases only at interpretation. Reference counts were treated as traces of process, not competence scores. After reconciliation, the final node definitions were applied to the full archive; excerpts were kept only when the same pattern appeared in at least two source types.

Trustworthiness, Ethics, and Transparency

The course instructor (the second author) was involved in the original redesign of the course. That involvement gave us contextual insight but also raised the possibility of interpretive

bias. Because the same course instructor designed and taught all sections, design features and teacher enactment remain intertwined in the archive. We tried to reduce over-interpretation by relying on independent rating for rubric-based measures, by keeping instructional conditions stable across cohorts, and by triangulating across multiple process sources rather than a single reflective account. Node frequencies in the qualitative phase were interpreted against archived excerpts, the wording of the instruments, and the structure of the learning tasks themselves.

Institutional ethics approval was obtained before data collection. Identifying details of the approving body and the approval reference are withheld for blind review and can be provided to the editor on request. All participants gave informed consent, and archived materials were anonymised before analysis. The full dataset is not publicly available because the archive contains potentially identifiable educational data. De-identified excerpts, coding definitions, and summary tables may be shared on reasonable request and subject to institutional ethics requirements.

AI-assisted language tools were used only after study design, data collection, analysis, and interpretation had been completed. In the earlier copy-editing stage, Grammarly Pro was limited to spelling, grammar, punctuation, awkward-phrasing alerts, and basic readability or formatting prompts of the kind a copy-editor might flag. Grammarly Pro's generative writing functions were not used, and outputs from Generate, Rewrite, Paraphrase, Ideas, Shorten, or comparable generative rephrasing functions were not accepted or retained. No AI tool was used to create research ideas, generate findings, code data, perform statistical operations, interpret results, select excerpts, or replace authorial judgment. The authors checked the revised wording against the underlying archive, made the final decisions, and take full responsibility for the manuscript.

Research Results

Stage 1: Exploratory Classroom Comparison

The archived baseline diagnostics indicated no obvious imbalance between the two intact classes in touch and tone control, rhythmic stability, or sight reading at the start of the course. This judgement does not rule out selection effects or other pre-existing differences. It supports only a limited claim: the two classes were not visibly mismatched at baseline. The baseline summaries are therefore used to describe initial classroom comparability, not to support inferential claims.

Across two semesters, the aligned group completed and passed more checkpoint tasks and reported longer daily practice time than the comparison group. Table 4 reports the descriptive summaries. The aligned class moved more often from task attempt to documented threshold attainment within the shared task bank, and its members logged more minutes of daily practice. These figures are read as classroom-level indicators that motivate the process analysis, not as evidence of an effect.

Earlier versions of the archived output included a large effect-size estimate for the checkpoint measure. That estimate is no longer reported. With ten students per group, and without preserved medians, interquartile ranges, Mann-Whitney U values, or individual-level distributions, we cannot inspect whether outliers, skew, or other distributional features shaped the estimate. Table 4 therefore stays with the descriptive summaries that the archive preserved. The difference between group means is used only as a classroom-level pattern for Stage 2 to explain; it is not treated as an effect-size estimate or as evidence of causality.

Table 4
Stage 1 Continuous Outcomes from Archived Summary Records (Descriptive Only)

Measure	Aligned Group M (SD), <i>n</i> = 10	Comparison Group M (SD), <i>n</i> = 10	Descriptive Difference (<i>M</i> ₁ – <i>M</i> ₂)
Checkpoint tasks passed from the shared course bank	28.67 (3.21)	11.58 (2.86)	17.09
Daily practice time (minutes)	59.37 (8.65)	50.68 (9.12)	8.69

Note. Values reproduce the descriptive summaries preserved in the archived Stage 1 output. The checkpoint measure refers to threshold-approved tasks from the shared course bank, not counts of full-length pieces. Inferential statistics are not reported because the archived summary did not retain Mann-Whitney U values, medians, or interquartile ranges, and inferential testing was judged inappropriate given the sample size and intact-class design under a single instructor. The classroom-level contrast is reported as an exploratory directional indicator that motivates Stage 2.

Attainment counts at the end of the course pointed in the same direction. On each rubric dimension, the aligned group contained more students who met the benchmark than the comparison group. The strongest contrast concerned pedagogical explanation and demonstration: eight of ten aligned students reached the benchmark, compared with three of ten in the comparison group. No formal significance test is reported for these counts. For the reasons stated in Data Analysis, they are used only as a classroom-level pattern to be interpreted alongside the process archive.

Table 5
Stage 1 Attainment Counts on the End-of-Course Assessment (Descriptive Only)

Dimension	Aligned Group Attained (<i>n</i> = 10)	Comparison Group Attained (<i>n</i> = 10)
Tone Control	9	7
Rhythmic Stability	8	6
Performance Presentation	7	6
Pedagogical Explanation and Demonstration	8	3

Note. The final pedagogical-explanation dimension corresponds to the archived rubric label teaching expression. Counts are reported as contextual pilot evidence from an intact-class comparison and should not be read as causal. Inferential statistics are not reported (see Data Analysis).

Stage 2: Process Evidence in Three Themes

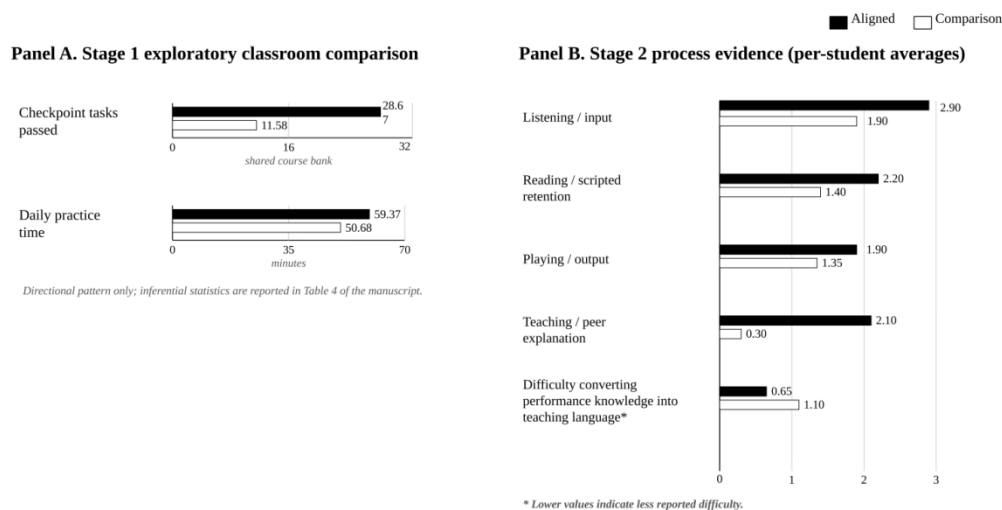
Table 6 reports the Stage 2 process markers for the two groups. Figure 2 places the descriptive Stage 1 patterns from Table 4 beside the Stage 2 markers from Table 6, giving readers a visual route into the integration. The following three themes then show how the coded traces appeared in ordinary course work and how they help make sense of the small-sample classroom pattern.

Table 6
Stage 2 Coded Process Markers

Process Node	Aligned References	Comparison References	Per-Student Average (A/C)	Interpretive Meaning
Listening / Input	58	38	2.90 / 1.90	Students identified modelled targets and performance contrasts
Reading / Scripted Retention	44	28	2.20 / 1.40	Students annotated scores and turned musical problems into usable scripts
Playing / Output	38	27	1.90 / 1.35	Students performed, monitored, and corrected their work
Teaching / Peer Explanation	42	6	2.10 / 0.30	Students explained, demonstrated, and guided peers
Difficulty turning performance knowledge into teachable language	13	22	0.65 / 1.10	Students struggled to convert performance experience into usable teaching language

Note. Reference counts come from the archived coding summaries and function as process markers. They do not serve as direct measures of ability. A/C = aligned/comparison.

Figure 2
Summary of Stage 1 outcome patterns and Stage 2 process evidence.



Making Tacit Performance Knowledge Explicit

Pedagogical explanation produced the clearest qualitative contrast. The aligned group generated 42 references to peer explanation; the comparison group generated six. The aligned group also showed fewer references to difficulty translating performance knowledge into teachable language, 13 against 22. The excerpts illustrate the difference. One comparison-group

student wrote: “My accompaniment keeps getting stuck. I know my fingers are not independent enough, but if I had to teach this later, I would not know how to tell elementary pupils, in words, where the effort should come from.” In an aligned-group microteaching plan, a student wrote: “During the demonstration, remind the peer to imagine the wrist as a spring-loaded shock absorber and to release immediately after the key is depressed.”

The two excerpts point to different stages of pedagogical work. The first recognises a technical difficulty but stops at recognition. The second converts an embodied action into an image, a demonstration point, and a correction strategy.

In the aligned materials, private sensation more often became public explanation. Students named the problem, connected it to a target, and planned a demonstration that a peer could try. Many entries also included a second attempt or a check on whether the cue had worked. Pedagogical explanation here is therefore not a matter of fluent speech alone. It requires choices: what to foreground, where to divide the movement or sound, which error is likely to occur, and what cue can support self-correction. The comparison materials tended to stop earlier, at problem recognition rather than preparation for another learner.

Visible Criteria Reshaped Self-Regulated Practice

Listening- and reading-related nodes were also more frequent in the aligned group: 58 versus 38 for listening, and 44 versus 28 for reading. These numbers suggest that modelled contrasts, score annotation, and script cards became part of the working method rather than peripheral preparation. Aligned-group logs usually followed a target-strategy-evidence-next-step structure. Comparison-group entries more often named errors, or noted a general need for more practice, without linking those observations to a criterion.

Longer practice time is not, on its own, a reliable sign of better learning. Students can repeat an unstable pattern for an hour and improve little. What the aligned logs suggested was narrower: practice time was more often tied to a target, a method, and a basis for judging progress. The weekly form supported that pattern by requiring target, indicator, and method entries before minutes could be recorded. These prompts do not prove learning by themselves, but they help explain why aligned-group records contained more criterion-linked self-monitoring and more specific statements about what would be checked next.

Reading and listening operated, in the aligned design, as organising actions rather than warm-ups. Students were asked to listen for contrasts, mark score features, prepare short verbal scripts, and then use those scripts during later playing and teaching. That sequence mattered because it gave students language before full performance stability had been reached. Rather than waiting until a passage felt automatic, the aligned class moved repeatedly between hearing, labelling, playing, and explaining.

Peer Teaching Created Pedagogical Accountability

Microteaching also brought accountability into the work. Under the aligned criteria, a student had to set a short objective, divide the demonstration into manageable steps, identify likely errors, and provide feedback that could be tested in a follow-up task. The plans and peer-feedback sheets show this shift. Aligned-group students more often described how they would isolate a rhythmic problem, simplify an accompaniment pattern, check whether a peer could reproduce the correction, or adapt the cue for later classroom use.

The rubric made that shift visible. In LO5, raters checked the fit between goal and task, the decomposition of the demonstration, the actionability of feedback, and the reusability of the transfer task. These criteria made teaching quality part of the threshold. Accurate playing alone was not enough for a student to meet the requirement.

The comparison group, by contrast, more often stopped at performance completion. Students recognised that a passage was difficult or that a coordination problem remained, but they less often documented how they would teach through that difficulty for someone else. The issue was not an absence of effort. It was the absence of routine occasions for making that effort pedagogically accountable.

Integrated Interpretation

Table 7 aligns the principal Stage 1 patterns with the process evidence that helps explain them. The integration does not treat the qualitative phase as proof of the quantitative phase. It shows, more modestly, how the process archive renders the small-sample classroom pattern more interpretable.

More checkpoint attainment lined up with visible thresholds and repeated evidence use. Longer reported practice lined up with target-strategy-evidence-next-step logs. The more favourable pedagogical-explanation pattern lined up with decomposed modelling, peer explanation, and fewer translation barriers. The contribution of the aligned design therefore appears to lie less in increasing activity than in reorganising how activity was interpreted, recorded, and recycled into later learning.

Table 7
Joint Display of Stage 1 Patterns, Stage 2 Process Evidence, and Integrated Inferences

Stage 1 Pattern	Stage 2 Process Evidence	Integrated Inference
More checkpoint tasks were attained in the aligned group.	Outcomes reappeared in logs, checkpoint sheets, and microteaching criteria; students more often moved from target to evidence to revision.	Visible thresholds made task completion legible and supported repeated movement from attempt to documented attainment.
Longer reported daily practice time appeared in the aligned group.	Aligned logs more often followed a target-strategy-evidence-next-step structure; listening and score reading were used as organising actions rather than preliminaries.	Practice time appears to have become more purposeful because time was attached to a visible target and a method of checking progress, rather than simply longer.
A more favourable end-of-course pattern appeared on pedagogical explanation and demonstration.	The aligned archive contained more peer explanation, more decomposed modelling, and fewer instances of difficulty turning performance knowledge into teachable language.	Embedded teach-back routines appeared to help students put tacit performance knowledge into words a peer could use.

Note. The joint display does not treat the qualitative phase as proof of the quantitative phase. Its function is explanatory: to show how the process archive makes the small-sample classroom pattern more interpretable.

Discussion

Alignment as a Practical Organiser

Alignment mattered in this course less as a slogan than as a set of small constraints on weekly work. In the comparison condition, practice could still mean sitting longer at the keyboard, repeating the assigned bars, and waiting for the course instructor’s next correction. The aligned group was asked to do something narrower and more visible: name the target,

attach it to a criterion, leave evidence of the attempt, and then try to teach the point to a peer. That change helps explain why their records contained more target-linked practice and more usable teaching language. This interpretation still has to remain cautious. One course instructor taught all sections, and the second author enacted the redesigned course; design effects, cohort effects, and instructor enactment therefore cannot be separated cleanly.

Visible criteria also shaped the work before assessment occurred. They directed attention and gave revision a point of reference. Students could see where effort should go, rather than waiting for a retrospective judgement (Brookhart, 2024; Sadler, 1989).

The process findings follow that logic. In the aligned group, logs more often named a target and connected that target to a next step. Score annotation and listening were used as preparation for later action, not as brief preliminaries. The LO-A-E matrix gave students a vocabulary for practice that was less available in the comparison condition. This reading is consistent with backward-design work when alignment is embedded in instructional activity rather than left at the planning stage (Kerimoğlu & Altun, 2024), and with programme-level studies of assessment mapping (Carss et al., 2023; Crawford et al., 2023). Newby and Cornelissen's (2025) warning still matters: constructive alignment should not become a totalising philosophy. The aim here is narrower. Expectations must be visible enough for students to practise with direction and for teachers to respond with evidence.

A Rival Hypothesis: Documentation Volume or Pedagogical Capability?

One rival explanation needs to be considered. The aligned group may look stronger because its students were required to leave more written traces, not because their pedagogical capability developed further. If documentation volume alone explains the pattern, the main claim of the study becomes much weaker.

The archive does not fit a simple volume explanation. If the issue were merely more writing, higher reference counts should appear across all five process nodes in roughly similar proportions. They do not. The largest gap appears on the teaching/peer-explanation node, where the per-student ratio is 2.10 to 0.30. That is about a seven-fold difference. On the playing/output node, where both groups had similar reasons to write, the difference is only 0.55 per student. The aligned-group surplus is concentrated where the LO-A-E matrix required pedagogical reasoning, rather than being spread evenly across the writing demands of the course.

The entries themselves also point beyond length. The comparison group did write about playing; students recorded errors, frustration, and awareness that something was wrong. What was often missing was the move from a recognised problem to a teachable explanation. The wrist-as-shock-absorber example works differently from the comparison student's statement about "where the effort should come from". It anticipates a peer's likely misunderstanding and sets up both the cue and the demonstration. More words alone would not account for that difference.

The LO5 rubric provides another check. To meet the aligned-group threshold, students had to show that the goal and task fitted together, that the demonstration decomposed the difficulty, that feedback could be verified through a second attempt, and that the transfer task could be reused. A long but generic plan would not have met those requirements. The aligned design did increase documentation, but it increased a particular kind of documentation: records had to display pedagogical reasoning before they counted toward the threshold.

The limitation remains. The archive cannot fully separate documentation volume from pedagogical capability. A cleaner test would require a comparison condition that demands equivalent documentation without the LO-A-E scaffolding. Until such work is done, this rival explanation should remain visible rather than dismissed.

Why Embedding Teaching within Skill Learning Mattered

The strongest difference between the two conditions was probably the decision to embed teaching inside skill learning, rather than postponing it to practicum or a later methods course. Students in the aligned group were repeatedly asked to explain fingering logic, model a technique, diagnose a problem, or offer a cue another learner could use. Shulman (1986) identified this kind of work as central to teaching: the transformation of private competence into publicly usable explanation.

The wrist-release plan makes the transformation concrete: a student framed the wrist as a spring-loaded hinge that releases after key contact. This was not simply a colourful phrase. It gave the peer a bodily image, a demonstration focus, and a correction to test. Similar moves appeared more often in the aligned group. That pattern sits well with microteaching research that emphasises low-stakes practice in explanation, feedback, and reflection before practicum (Iliasova et al., 2025). It also needs the cautions in the literature. Trent (2023) shows that microteaching can carry emotional pressure; Gunawardena (2023) shows that reflective structure helps keep the activity educative. In this course, the slots were brief, frequent, and criterion-supported, which may have kept teach-back developmental rather than merely evaluative.

Bringing teaching into the piano course also changed the standard of success. If the course rewards only accurate or expressive playing, students can remain in the role of individual performers. Once they must explain and demonstrate for a peer, they have to select the first feature to show, anticipate misunderstanding, judge which error matters most, and decide how improvement will be checked. Their own execution still matters, but it is no longer the whole task. Another learner's uptake becomes part of the work.

In Chinese music classrooms, teacher demonstration has long been a central pedagogical resource. Student-centred reform has not removed the visibility of modelling or teacher authority in music lessons (Zhang & Leung, 2023, 2025). The aligned course relocated part of that resource. Demonstration became something students had to prepare, decompose, and justify for peers, rather than something they mainly received from the instructor. In this limited sense, the design redistributed a familiar teacher-led practice for the preparation of future teachers.

Implications for Practical Teacher Education

The value of the LO-A-E design is not confined to music. Its broader relevance lies in a recurring problem across practical teacher education: candidates can often perform more than they can explain. Recent work on pre-service competencies in critical thinking, digital literacy, inclusive-schooling readiness, action research, and emotional preparation has reached a comparable conclusion, namely that professional capacities need to be made visible during preparation rather than assumed to appear later (Brígido Mero et al., 2024; Demir Evcimen et al., 2025; Durante, 2025; Kuzu & Erdoğan Kayabaşı, 2025; Protacio, 2025; Vančíková et al., 2025).

The design worked through several modest components rather than through a single intervention. Outcomes returned throughout the semester in logs, checkpoint sheets, and microteaching criteria, so students repeatedly encountered what counted as progress. The Listen-Read-Play-Teach cycle turned that return into a routine. The evidence trail then gave the instructor and students a record of practice, explanation, and revision that could be used in later feedback. Teach-back did not need to become a long weekly mini-lesson. Its value lay in being brief, regular, and tied to criteria.

Shulman's framework clarifies the extension made by this course. Practical teacher-education students often possess tacit knowledge before they can represent it for another learner. Courses therefore need tasks that convert that knowledge into language, cues, and

demonstrations. The same logic could travel to science methods, physical education, or laboratory-based teacher education, provided each practical task includes a short cycle of explaining, modelling, and checking.

Limitations and Future Research

Several limitations shape how this study should be read. The exploratory classroom comparison relied on intact classes from a single institution, one course instructor, and a very small sample. Quantitative patterns must therefore be read as contextual rather than causal evidence; cohort differences and instructor effects cannot be ruled out. The archived records preserved only limited participant information, with fuller demographic details unavailable. The archived quantitative summaries also did not preserve every statistic desirable for a full nonparametric report — medians, interquartile ranges, and Mann-Whitney U values were not retained, which is one reason Stage 1 is reported descriptively in the present version. No classroom video was available, so some aspects of embodied demonstration and peer response were inevitably lost. Because the qualitative materials were translated from Chinese archival sources, an additional interpretive layer is involved, even though translations were checked against the original wording. Stage 2 is therefore best understood as an explanatory extension within the same instructional context, not as an independent replication.

The rival-hypothesis concern returns here. Future studies should include a comparison condition that demands equivalent documentation without the LO-A-E scaffolding, so that the contribution of pedagogical content and the contribution of writing volume can be separated more cleanly than is possible in the present archive.

These limitations lead to a focused research agenda. Multi-site work could test whether similar alignment structures support pedagogical explanation beyond one course and could separate design from instructor effects more convincingly. Video, stimulated recall, and classroom interaction analysis would make the movement from self-regulation to explanation easier to trace. Follow-up into practicum would show whether explanations rehearsed in a skill course survive in school classrooms. Another useful line would examine cognitive load: staging listening, reading, playing, and teaching across time may help candidates manage the combined demands of performing and instructing. In music education, future work should also connect course-level design with Chinese assessment reforms and with how schools recognise teacher candidates' teaching ability (Chen & Tu, 2025; Zhang et al., 2025; Zhang et al., 2026).

Conclusions and Implications

The two-stage exploration points to a modest design claim. In the aligned group, practice became easier to see and review: targets remained visible, expectations were repeated, and competence had to be demonstrated for someone else. The Stage 1 figures — more checkpoint attainment, longer reported practice, and more students meeting the pedagogical-explanation benchmark — are therefore treated as a classroom-level indicator for RQ1, not as evidence of an effect. Stage 2 explains where that indicator had substance. Pedagogical explanation and demonstration appeared through repeated movement among hearing, labelling, playing, and teach-back, with logs, score annotation, decomposed modelling, and peer explanation supplying the main traces (RQ2).

Across the two stages, three features carried most of the design work. Visible criteria gave students a working language. Recurring teach-back gave tacit performance knowledge a public form. A light evidence trail made feedback and revision possible across weeks (RQ3). For practical teacher education, the implication is direct: a course that asks students to perform and to teach must build the passage from performance to explanation into ordinary coursework.

The contribution lies in the combination, not in a general claim that microteaching helps. Used together, visible criteria, teach-back, and revisitable evidence can make performance knowledge more teachable inside an ordinary practical course.

These conclusions should be read as design-oriented propositions for future research, not as evidence of treatment efficacy. The next test should use cleaner conditions: multiple instructors, multiple sites, and a documentation-equivalent comparison condition.

Acknowledgments and Language-Editing Disclosure

The authors thank the School of Music, Jiangxi Normal University, for institutional and logistical support related to the instructional implementation and the organization of archived course records. Grammarly Pro was used only for limited English-language editing to improve clarity and grammar after study design, data collection, analysis, and interpretation had been completed. Its use was restricted to linguistic refinement. All substantive content, intellectual contributions, analytic decisions, and final wording were generated, reviewed, and approved by the human authors, who take full responsibility for the manuscript.

Ethics

Institutional ethics approval was obtained prior to data collection from the School of Music, Jiangxi Normal University (Approval No. IRP-JXNU-SOM-2025047), and all participants provided informed consent. The ethics approval form is supplied as a separate submission file.

Declaration of Interest

The authors declare no competing interest.

References

- Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education*, 32(3), 347–364. <https://doi.org/10.1007/BF00138871>
- Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university* (4th ed.). Open University Press.
- Blackwell, J., & Matherne, N. (2024). Developing feedback skills in preservice music teachers. *International Journal of Music Education*, 42(2), 243–256. <https://doi.org/10.1177/02557614231163237>
- Blackwell, J., Matherne, N., & McPherson, G. E. (2023). A PRISMA review of research on feedback in music education and music psychology. *Psychology of Music*, 51(3), 716–729. <https://doi.org/10.1177/03057356221109328>
- Brígido Mero, M., Rodríguez de Castro, A., Lejárraga García, A., Laviña Pérez, I., & Nistal Anta, V. (2024). Emotional training for prospective teachers in science education. *Problems of Education in the 21st Century*, 82(2), 236–251. <https://doi.org/10.33225/pec/24.82.236>
- Brooks, C., Carroll, A., Gillies, R. M., & Hattie, J. (2019). A matrix of feedback for learning. *Australian Journal of Teacher Education*, 44(4), 14–32. <https://doi.org/10.14221/ajte.2018v44n4.2>
- Brookhart, S. M. (2024). Educational assessment knowledge and skills for teachers revisited. *Education Sciences*, 14(7), Article 751. <https://doi.org/10.3390/educsci14070751>
- Cano García, E. (2024). Peer feedback for teaching professional development: Conditions for it to take effect. *Cogent Education*, 11(1), Article 2391577. <https://doi.org/10.1080/2331186X.2024.2391577>
- Carss, W., Cowie, B., & Cook, S. (2023). Mapping assessment tasks and lecturer considerations: A case study of a NZ primary teacher education programme. *Australian Journal of Teacher Education*, 48(9), 100–114. <https://doi.org/10.14221/1835-517X.6624>
- Cavanagh, M., & Tran, D. (2025). Pre-service teachers' feedback on their peers' lesson plans. *Asia-Pacific Journal of Teacher Education*, 53(4), 464–478. <https://doi.org/10.1080/1359866X.2025.2539240>

- Chen, L., & Tu, C. (2025). Chinese secondary school teachers' perceptions of teacher candidates' teaching ability and performance. *Australian Journal of Teacher Education*, 50(3), 35–53. <https://doi.org/10.14221/1835-517X.6413>
- Crawford, R., Jenkins, L. E., & Wan, L. (2023). Experiential learning projects as assessment in initial teacher education. *Australian Journal of Teacher Education*, 48(1), 37–54. <https://doi.org/10.14221/1835-517X.5787>
- Cui, C., Xie, X., & Yin, Y. (2024). Exploring the relationships among music performance anxiety, teaching anxiety, and self-efficacy of Chinese preservice music teachers. *Frontiers in Psychology*, 15, Article 1373454. <https://doi.org/10.3389/fpsyg.2024.1373454>
- Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, 57(3), 300–314. <https://doi.org/10.1177/0022487105285962>
- Demir Evcimen, F. B., Ulukaya Öteleş, Ü., & Koçoğlu, E. (2025). The effect of critical thinking practices on digital footprint. *Problems of Education in the 21st Century*, 83(3), 306–322. <https://doi.org/10.33225/pec/25.83.306>
- Dragnić-Cindrić, D., & Anderson, J. L. (2025). Developing pre-service teachers' pedagogical content knowledge: Lessons from a science methods class. *Education Sciences*, 15(7), Article 860. <https://doi.org/10.3390/educsci15070860>
- Durante, P. G. C. (2025). Advancing critical literacy through critical literature pedagogy-based principles of literary education. *Problems of Education in the 21st Century*, 83(2), 196–217. <https://doi.org/10.33225/pec/25.83.196>
- Franke, U., Backfisch, I., Scherzinger, L., Lachner, A., Scheiter, K., & Stürmer, K. (2024). Do prompts and strategy instruction contribute to pre-service teachers' peer-feedback on technology integration? *Educational Technology Research and Development*, 72, 3117–3138. <https://doi.org/10.1007/s11423-024-10403-8>
- Gunawardena, M. (2023). Mentoring pre-service teachers: The THIINK4 reflective cycle. *Australian Journal of Teacher Education*, 48(4), 19–37. <https://doi.org/10.14221/1835-517X.5901>
- Harden, R. M. (2007). Outcome-based education: The future is today. *Medical Teacher*, 29(7), 625–629. <https://doi.org/10.1080/01421590701729930>
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81–112. <https://doi.org/10.3102/003465430298487>
- Iliasova, L., Nekrasova, I., Mena, J., & Estrada-Molina, O. (2025). Microteaching on pre-service teachers' education: Literature review. *Frontiers in Education*, 10, Article 1562975. <https://doi.org/10.3389/feduc.2025.1562975>
- Jones, S. E., & Clarke, D. (2025). Enhancing pre-service teachers' preparedness for professional experience placement and employment: Authentic school-university partnership opportunities. *Australian Journal of Teacher Education*, 50(3), 121–145. <https://doi.org/10.14221/1835-517X.6974>
- Kerimoğlu, E., & Altun, S. (2024). Backward design in pre-service teacher education to enhance curriculum knowledge. *Journal of Teaching and Learning*, 18(2), 128–149. <https://doi.org/10.22329/jtl.v18i2.8625>
- Kong, S.-H. (2025). Music education training for kindergarten teachers: A workshop integrating Shulman's pedagogical content knowledge and pedagogical reasoning and action model. *Journal of Early Childhood Teacher Education*, 46(1), 85–102. <https://doi.org/10.1080/10901027.2024.2410399>
- Kuzu, Ç. İ., & Erdoğan Kayabaşı, K. (2025). Determining the digital literacy levels of mathematics pre-service teachers. *Problems of Education in the 21st Century*, 83(4), 563–578. <https://doi.org/10.33225/pec/25.83.563>
- McPherson, G. E., & Blackwell, J. (2025). Teacher feedback in collegiate instrumental music lessons. *Journal of Research in Music Education*, 73(2), 217–236. <https://doi.org/10.1177/00224294241265014>
- Newby, L., & Cornelissen, L. (2025). A neutral toolkit? For a fundamental critique of constructive alignment. *Teaching in Higher Education*, 30(7), 1687–1702. <https://doi.org/10.1080/13562517.2025.2465987>
- Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199–218. <https://doi.org/10.1080/03075070600572090>
- Okumu, M. O., Lammert, C., & Hargura, H. M. (2024). Teacher candidates' perceptions of peer and instructor feedback through video annotations: Whose advice do they prefer? *Education Sciences*, 14(12), Article 1361. <https://doi.org/10.3390/educsci14121361>

- Pale, M., Ohi, S., & Kee, L. (2023). Towards pre-service teachers' theory-praxis nexus in early years English and literacy education: A pilot study. *Australian Journal of Teacher Education*, 48(1), 55–73. <https://doi.org/10.14221/1835-517X.5880>
- Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, 8, Article 422. <https://doi.org/10.3389/fpsyg.2017.00422>
- Protacio, J. V. (2025). Predictors of concept formation and educational contextualization competencies in geometry of pre-service mathematics teachers. *Problems of Education in the 21st Century*, 83(2), 218–236. <https://doi.org/10.33225/pec/25.83.218>
- Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, 18(2), 119–144. <https://doi.org/10.1007/BF00117714>
- Shaw, L. (2024). Conservatoire students' perspectives on instrumental music teacher education: Developing pedagogical knowledge for the future music education workforce. *Journal of Education for Teaching*, 50(1), 155–171. <https://doi.org/10.1080/02607476.2023.2228233>
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189X015002004>
- Spooner-Lane, R., Broadley, T., Curtis, E., & Grainger, P. (2023). Development of a teaching performance assessment in Australia: What did we learn? *Australian Journal of Teacher Education*, 48(1), 1–16. <https://doi.org/10.14221/1835-517X.5692>
- Trent, J. (2023). How are preservice teachers discursively positioned during microteaching? The views of student teachers in Hong Kong. *Australian Journal of Teacher Education*, 48(6), 80–97. <https://doi.org/10.14221/1835-517X.6124>
- Tucker, O. G., Nicholson, G., & Jordan, R. C. (2025). Navigating competing demands within music teacher education: Biesta's three domains of educational purpose. *International Journal of Education & the Arts*, 26(25). <https://doi.org/10.26209/ijea26n25>
- Vančíková, K., Čiliaková, R., & Hušlová Orságová, M. (2025). Conceptualizations of inclusive schooling by pre-service teachers in Slovakia. *Problems of Education in the 21st Century*, 83(5), 689–704. <https://doi.org/10.33225/pec/25.83.689>
- Weidner, B. N., Wilson, J., & Royston, N. S. (2025). Self-study of faculty perspectives of music teacher education curricular reform. *International Journal of Education & the Arts*, 26(23). <https://doi.org/10.26209/ijea26n23>
- Young, M. M. (2013). University-level group piano instruction and professional musicians. *Music Education Research*, 15(1), 59–73. <https://doi.org/10.1080/14613808.2012.737773>
- Zhang, L.-X., & Leung, B.-W. (2023). Context matters: Adaptation of student-centred education in China school music classrooms. *Music Education Research*, 25(4), 418–434. <https://doi.org/10.1080/14613808.2023.2230587>
- Zhang, L.-X., & Leung, B.-W. (2025). Defining music demonstration lessons: A unique performance-based lesson type improving teachers' instructional skills in Chinese mainland education. *British Journal of Music Education*, 42(1), 65–79. <https://doi.org/10.1017/S0265051724000214>
- Zhang, L.-X., Yan, Z., & Wang, X. (2025). Understanding music teachers' formative assessment intention and implementation: A Chinese mainland context. *International Journal of Music Education*, 43(1), 44–60. <https://doi.org/10.1177/02557614251315461>
- Zhang, L.-X., Qiu, Y., Zou, Y., & Yan, Z. (2026). From policy to practice: A longitudinal interview study of experienced music teachers on implementing formative assessment in China. *Music Education Research*. Advance online publication. <https://doi.org/10.1080/14613808.2026.2615436>

Received: March 18, 2026

Revised: April 28, 2026

Accepted: June 18, 2026

Cite as: Xu, M., Li, P., Zhou, B., & Yi, X. (2026). Making performance teachable: Curricular alignment and microteaching in group piano teacher education. *Problems of Education in the 21st Century*, 84(3), 505–524. <https://doi.org/10.33225/pec/26.84.505>

Min Xu (Corresponding author)	PhD, Senior Lecturer, School of Music, Jiangxi Normal University, Ziyang Avenue 99, Nanchang, Jiangxi 330022, P. R. China E-mail: xumin@jxnu.edu.cn ORCID: https://orcid.org/0009-0003-5183-3635
Pan Li	PhD, Associate Professor, School of Music, Jiangxi Normal University, Ziyang Avenue 99, Nanchang, Jiangxi 330022, P. R. China E-mail: 004937@jxnu.edu.cn ORCID: https://orcid.org/0009-0009-2514-2893
Baiyun Zhou	PhD, Senior Lecturer, School of Music, Jiangxi Normal University, Ziyang Avenue 99, Nanchang, Jiangxi 330022, P. R. China E-mail: 005845@jxnu.edu.cn ORCID: https://orcid.org/0009-0007-4715-9392
Xuan Yi	PhD, Senior Lecturer, School of Music, Jiangxi Normal University, Ziyang Avenue 99, Nanchang, Jiangxi 330022, P. R. China E-mail: 005856@jxnu.edu.cn ORCID: https://orcid.org/0009-0007-9387-2308

DIGITAL TECHNOLOGIES IN VOCATIONAL EDUCATION: FROM TECHNOLOGY ADOPTION TO SOCIO-TECHNICAL TRANSFORMATION

Bo Zhou, Seong Pek Lim, Nahdia Kabir

INTI International University, Malaysia

E-mail: i24028791@student.newinti.edu.my, seongpek.lim@newinti.edu.my,
i24028316@student.newinti.edu.my

Jin Tao

Yangzhou Polytechnic Institute, P. R. China

E-mail: i24028010@student.newinti.edu.my

Jiaying Yang

South China Normal University, P. R. China

E-mail: yjylsz@foxmail.com

Cong Wang

INTI International University, Malaysia

E-mail: i24026767@student.newinti.edu.my

Abstract

In response to rapid digitalisation, vocational education has increasingly integrated digital technologies such as artificial intelligence (AI) and information and communication technologies (ICT), changing how skills are taught and developed. Although research in this area has grown rapidly, the field still lacks a clear overview of its knowledge structure, major themes, and emerging directions. To address this gap, this study aims to map the knowledge structure, thematic patterns, and emerging directions of research on digital technologies in vocational education. It analyses 203 articles retrieved from the Web of Science (WoS) Core Collection for the period 2021–2025, following a PRISMA-guided screening procedure. Using VOSviewer and CiteSpace, the study conducted performance analysis, bibliographic coupling, keyword co-occurrence analysis, and burst detection to identify publication patterns, thematic clusters, and research frontiers. The findings reveal four major directions of inquiry: learner empowerment and sustainability, teacher digital competence, institutional innovation, and policy-oriented skill development in the context of Industry 4.0. Burst detection further suggests an emerging movement in research attention from technology-focused adoption toward more human-centred, pedagogical, and governance-related perspectives. Overall, the study contributes to the field by clarifying both the intellectual structure and the changing priorities of research on digital transformation in vocational education. It also advances current understanding by showing that digital transformation is increasingly framed not simply as technology adoption, but as a socio-technical process shaped by pedagogy, governance, inclusion, and ethical responsibility.

Keywords: digital transformation, vocational education, bibliometric analysis, digital competence, industry 4.0

Introduction

Vocational education is increasingly expected to prepare learners for workplaces shaped by digital tools, data-based processes, and changing skill requirements. These changes have made digital transformation a major concern for vocational education, as institutions need to update teaching practices, strengthen learners' digital competence, and ensure that vocational skills remain relevant to labour market needs (UNESCO, 2021; OECD, 2023). Within this context, digital technologies have attracted growing attention as tools for improving educational quality and supporting skills formation in the era of Industry 4.0. Artificial intelligence (AI) and information and communication technologies (ICT), in particular, have emerged as prominent areas of research and practice in vocational education (Bolaños & Pilerot, 2021; Vilppola et al., 2022).

However, the integration of digital technologies into vocational education is far from straightforward. AI-supported functions such as intelligent tutoring, automated feedback, and predictive analytics often operate alongside more established ICT tools. Together, they can complicate teaching and learning and raise questions about effectiveness, fairness, and accountability. These challenges are further shaped by differences in teachers' digital competence and willingness to adopt technology (Yang et al., 2023). They are also reinforced by the difficulty of applying digital tools in work-based learning settings, which are a core part of vocational education (Enochsson et al., 2021). For vocational education institutions, a key challenge is to ensure that technological innovation remains aligned with evolving skill demands in the context of Industry 4.0 (Albizu & Estensoro, 2024; Aranda et al., 2023). Understanding how digital technologies, particularly AI and ICT, are addressed in vocational education research is therefore essential for supporting forms of digital transformation that are both context-sensitive and socially responsible.

These concerns extend beyond individual institutions or national systems. Across different vocational education contexts, institutions are being asked to respond to similar changes in work, including automation, data use, platform-based employment, and digitally mediated collaboration. At the same time, the ways in which digital transformation is implemented vary according to policy priorities, infrastructure, teacher readiness, institutional capacity, and links with industry. These contextual differences are also reflected in recent studies on AI integration in vocational and technical education, where institutional policy support and teachers' GenAI adoption have been identified as important conditions for technology use (Ayanwale et al., 2025; Cui & Li, 2025). This combination of shared pressures and context-specific conditions gives the topic clear international relevance. It also suggests the need to examine how digital technologies have been studied across vocational education contexts and how recent research in the field appears to be moving from a narrow focus on technology adoption toward a wider concern with socio-technical transformation.

Research in this area has grown rapidly, alongside the broader acceleration of digitalisation agendas in education during the COVID-19 pandemic (Zawacki-Richter, 2021). Existing studies can be broadly grouped into several related areas. One line of research has examined digital pedagogy and the use of technology to support teaching and learning in vocational settings. Another has focused on teachers' digital competence, professional readiness, and technology adoption. A further body of work has considered institutional preparedness, policy support, and the conditions needed for digital transformation in vocational education (Hassan et al., 2021; Jiang et al., 2024). Earlier reviews and conceptual analyses have also provided useful insights into specific areas such as digital literacy development, game-based learning, technology adoption, and teacher professional preparation (Dahalan et al., 2023; Rusa et al., 2023). However, these studies tend to address separate aspects of digital transformation rather than showing how the field as a whole has evolved.

Collectively, the existing literature points to several unresolved issues. The intellectual structure of the field has not yet been clearly established. It remains difficult to see which areas of research have been most influential, how key themes are connected, and which topics are beginning to shape future directions. Existing syntheses have often focused on particular technologies, teaching applications, or policy discussions, with less attention given to the relationships among learners, teachers, institutions, and labour-market needs. A clearer understanding of these relationships is important for international readers and stakeholders, as curriculum reform, teacher development, technology investment, and policy design increasingly depend on how digital transformation is understood across vocational education contexts.

Against this background, this study examines research on digital technologies in vocational education, with particular attention to AI- and ICT-related scholarship. By analysing publication trends, citation impact, thematic connections, and emerging topics, the study identifies the field's structural characteristics, thematic development, and broader socio-technical concerns. The study is guided by three research questions:

RQ1: How have publication trends and citation impact evolved in research on digital technologies in vocational education?

RQ2: How is the intellectual and thematic structure of the field organised across learner, teacher, institutional, and policy levels?

RQ3: Which emerging topics represent current research frontiers?

Research Methodology

General Background

This study adopted a bibliometric research design to analyse research on digital technologies in vocational education, with particular attention to AI and ICT. In this study, digital technologies were treated as a broad concept that included AI- and ICT-related research, which formed the core scope of the search strategy. Bibliometric analysis has become a widely recognized quantitative method for systematically mapping scientific knowledge and tracing how research fields evolve over time (Bo et al., 2025; Donthu et al., 2021). By combining statistical indicators with network visualization, it enables the identification of emerging topics, conceptual developments, and intellectual connections among publications (Morál-Muñoz et al., 2020; Zhou et al., 2026b). In contrast to narrative reviews, this data-driven method generates transparent and visually oriented representations that allow for a more accurate understanding of research structures and their temporal dynamics (Öztürk et al., 2024; Zhou et al., 2026a).

In this study, the method was used to visualize the field's intellectual structure, identify key thematic clusters, and trace research evolution over time. This provided a quantitative basis for understanding the development of the field and for guiding future educational innovation. To ensure a systematic procedure, the study was carried out in four sequential stages: data collection, PRISMA-guided screening, bibliometric analysis and visualization, and interpretation of the results.

Data Collection

The criteria used for data collection are summarised in Table 1. All bibliographic records were retrieved from the Web of Science (WoS) Core Collection. The WoS Core Collection was selected because it provides standardised bibliographic metadata, consistent indexing criteria, and citation information suitable for bibliometric analysis (Zawacki-Richter et al., 2019). Although other databases such as Scopus, ERIC, and Google Scholar are also important sources for education research, the use of a single database helped maintain consistency in

indexing standards, document classification, and citation data. The dataset covered the period from 2021 to 2025, during which digital and intelligent transformation accelerated in the post-COVID-19 context. In this study, vocational education was used as an umbrella term covering vocational education and training (VET), technical and vocational education and training (TVET), technical and vocational education (TVE), and related terms used in different national or regional contexts. Although “career and technical education” (CTE) is more commonly used in North American contexts, it was included in the search strategy to improve retrieval coverage. In the analysis, CTE was treated as a related regional term within the broader field of vocational and technical education, rather than as a separate conceptual boundary. Boolean operators were used to limit the results to peer-reviewed journal articles indexed in SSCI, ESCI, or SCI-Expanded, thereby enhancing the reliability and reproducibility of the dataset. The search process employed the following Boolean query:

TS = ((“digital technology” OR “AI” OR “artificial intelligence” OR “ICT” OR “Information and Communication Technology”) AND (“vocational education” OR “technical and vocational education” OR “technical and vocational education and training” OR “vocational education and training” OR “vocational training” OR “career and technical education” OR “TVET” OR “TVE” OR “VET” OR “CTE”)).

All records were downloaded on January 1, 2026, and the final dataset was subsequently prepared for bibliometric analysis and visualization.

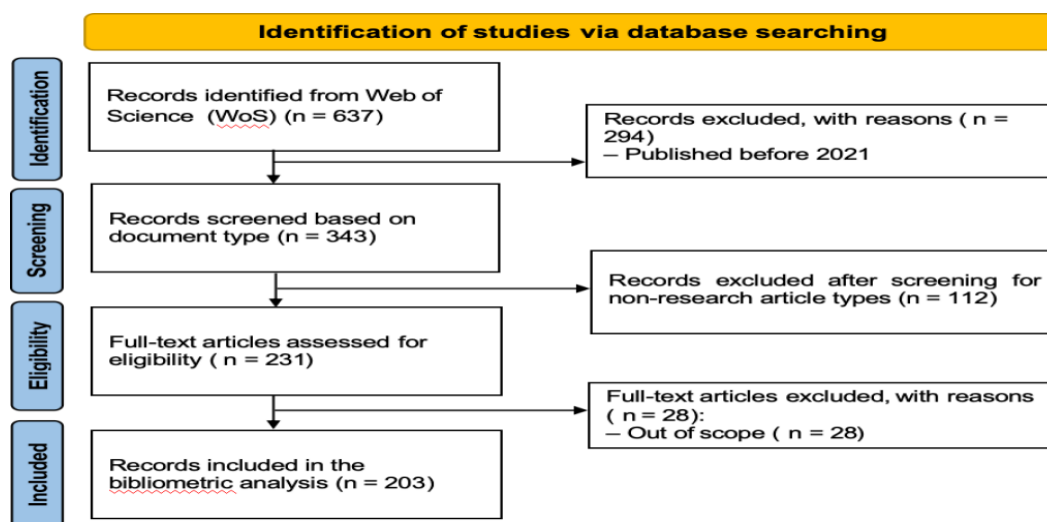
Table 1
Inclusion Criteria for Bibliometric Analysis

WoS Database	Core Collection
Time period	2021 to 2025
Search field	TS
Search keywords	((“digital technology” OR “AI” OR “artificial intelligence” OR “ICT” OR “Information and Communication Technology”) AND (“vocational education” OR “technical and vocational education” OR “technical and vocational education and training” OR “vocational education and training” OR “vocational training” OR “career and technical education” OR “TVET” OR “TVE” OR “VET” OR “CTE”))
Document type	Article
Language	English
WoS Indexes	SSCI / ESCI / SCI-EXPANDED

Instrument and Procedures

The instruments used in this study included the WoS Core Collection for data retrieval and the PRISMA framework for systematic screening and selection. The overall data screening and selection procedure is presented in Figure 1, following the PRISMA stages of identification, screening, eligibility, and inclusion (Page et al., 2021). A total of 637 bibliographic records were initially retrieved from the WoS Core Collection. After applying the publication year filter (2021–2025), 294 records were excluded for falling outside the specified time frame. After this step, 343 records remained for document-type screening. Among these, 112 items, such as editorials, conference papers, and book reviews, were removed because they were not classified as peer-reviewed journal articles. The remaining 231 records were further assessed for eligibility, resulting in the exclusion of 28 non-English publications. In the final stage, 203 studies met all predefined inclusion criteria and were retained for bibliometric analysis. This multi-stage screening procedure ensured that the dataset included only eligible peer-reviewed, English-language publications, which improved the rigour and transparency of the study.

Figure 1
PRISMA Flowchart



Data Analysis

The final dataset was analysed using VOSviewer (version 1.6.20) and CiteSpace (version 6.3.R1, 64-bit Advanced) to examine the intellectual structure and thematic development of research on digital technologies in vocational education. Four bibliometric approaches were used. Performance analysis assessed publication productivity and citation impact. Bibliographic coupling analysis examined intellectual linkages among documents; a minimum citation threshold of four was applied, and 60 of the 203 documents met this criterion. Co-occurrence analysis explored thematic structures based on keyword frequency and co-appearance patterns; a minimum occurrence threshold of 14 was applied, and 59 of the 6,519 extracted terms satisfied this threshold. The citation and co-occurrence thresholds were determined through preliminary testing of different cut-off points. The citation threshold of four retained a manageable and interpretable bibliographic coupling network, while the co-occurrence threshold of 14 reduced low-frequency noise and preserved sufficient keywords for meaningful thematic interpretation. Burst-detection analysis identified emerging topics and shifts in research attention over time. The parameter configuration was set as follows: $\alpha_1/\alpha_0 = 2.0$, $\alpha_i/\alpha_{i-1} = 2.0$, $\gamma = 0.6$, and a minimum duration of 1. These approaches provided a systematic basis for examining the structural organization and thematic evolution of the field. In this context, bibliographic coupling was particularly useful for identifying shared knowledge bases among recent studies, while keyword co-occurrence helped reveal dominant themes and conceptual linkages.

Research Results

Performance Analysis

The bibliometric performance analysis of research on digital technologies in vocational education from 2021 to 2025 provides an overview of the field's academic productivity and citation impact. Table 2 shows the main bibliometric indicators derived from the WoS Core Collection, including total publications, citing documents, total citations, average citations per item, and the H-index. The dataset comprised 203 publications, which collectively received

814 citations, or 792 excluding self-citations. These publications were cited by 776 distinct citing documents, or 756 excluding self-citations, resulting in an average of 4.01 citations per item. An H-index of 11 indicates that at least 11 publications were cited 11 times or more, reflecting a moderate but steadily growing academic presence in the field. Figure 2 depicts the yearly distribution of publications and citations in the selected literature. The light-purple bars represent the volume of publications, whereas the dark-blue line indicates citation counts. Both indicators show a steady upward trend from 2021 to 2025, with the highest values recorded in 2025. This pattern reflects the continuing expansion of research interest in digital technologies in vocational education and underscores the growing visibility of this field.

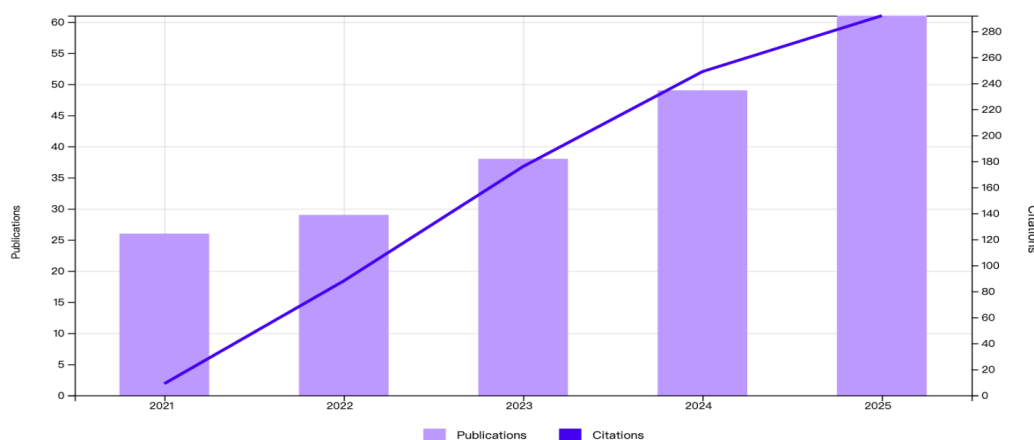
Table 2

Overview of Bibliometric Performance Indicators (2021 to 2025)

Metric	Value
Total Publications	203
Total Citing Articles	776 (756 excluding self-citations)
Total Citations	814 (792 excluding self-citations)
Average Citations per Item	4.01
H-Index	11

Figure 2

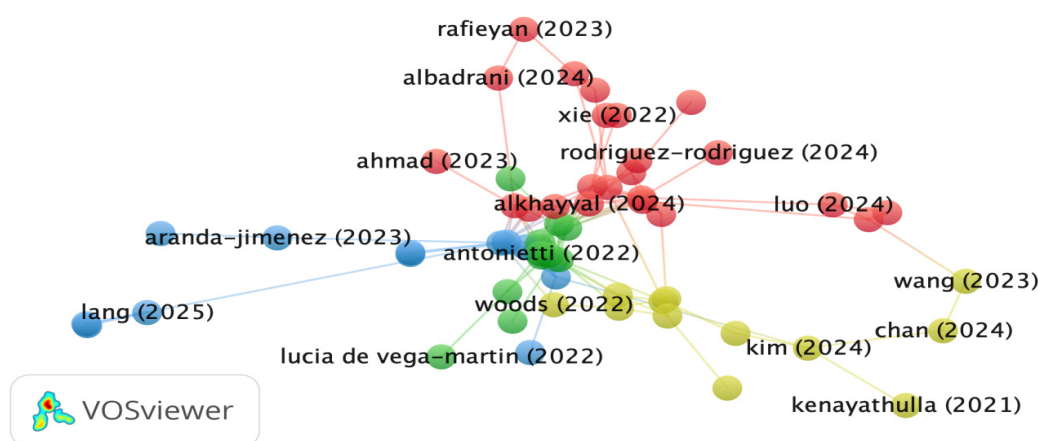
Annual Publication and Citation Trends (WoS database)



Bibliographic Coupling Analysis by Clusters

The bibliographic coupling analysis identified four major clusters, revealing the principal intellectual connections and thematic groupings among the selected studies. As shown in Figure 3, the final network comprised 60 documents, 127 links, and a total link strength of 212. In the visualisation, each colour represents a distinct research cluster, reflecting a particular line of inquiry in the field. Table 3 summarises the four clusters together with their representative publications and thematic orientations.

Figure 3
Bibliographic Coupling Analysis (VOSviewer visualization)



Cluster 1 (Red), with 23 publications, is anchored in a shared reference base concerning digital technologies, AI-enabled learning, learner empowerment, employability, and sustainability in vocational education. Its thematic configuration links self-directed learning, digital engagement, AI literacy, psychological well-being, ethical awareness, and sustainable skill development. Beyond the functional use of digital technologies, this cluster indicates an expanding research interest in the role of AI in supporting learner development, social inclusion, and sustainability in vocational education (Ahmad et al., 2023; Avsec & Rupnik, 2025; Cai et al., 2024). This suggests that the literature is gradually extending beyond performance-oriented applications toward a broader understanding of AI-enabled vocational education.

Cluster 2 (Green), comprising 13 articles, brings together research on teachers' acceptance, digital competence, and institutional readiness for technology integration in vocational education. The common intellectual foundation of this cluster lies in its focus on technology acceptance, teacher beliefs, self-efficacy, ICT competence, professional preparation, and institutional support. Rather than viewing digital transformation as a matter of individual readiness alone, this cluster emphasises the role of organisational and pedagogical conditions in sustaining technology integration (Edeh et al., 2021; Vilppola et al., 2022; Yang et al., 2023). It also highlights the need to align teacher preparation, professional learning, and institutional support.

Cluster 3 (Blue), including 12 studies, is organised around institutional innovation, leadership adaptation, and organisational transformation in vocational education. Its conceptual links connect digital transformation, visionary leadership, workforce development, cross-sector collaboration, value co-creation, and Industry 4.0-oriented organisational change. In this cluster, AI is examined not only as an educational technology but also as part of a wider institutional infrastructure that supports governance, collaboration, workforce competence, and innovation (Aranda et al., 2023; Badawi & Drăgoicea, 2023; Han et al., 2023). The cluster therefore reflects an organisational-level perspective on AI integration, with particular attention to institutional adaptation and transformation.

Cluster 4 (Yellow) consists of 12 publications linked by a shared focus on policy directions, lifelong learning, future skill development, and Industry 4.0-related workforce preparation. Its thematic pattern highlights connections among graduate readiness, policy alignment, adaptability, professional resilience, educational-industrial partnerships, and future-ready competencies. In this cluster, AI and digital transformation are discussed in relation

to broader policy and workforce-development concerns, particularly lifelong learning and cross-sector collaboration in preparing vocational education systems for future labour market demands (Hearn et al., 2023; Kenayathulla, 2021; Kim et al., 2024). This cluster presents a policy-oriented knowledge structure in which technological change, employability, and lifelong learning are closely interconnected.

Table 3
Bibliographic Coupling by Cluster

Cluster No. & Colour	Cluster Labels	No. of Articles	Representative Publications
Cluster 1 (Red)	AI, Learner Empowerment, and Sustainable Development in Vocational Education	23	Ahmad et al. (2023), Avsec and Rupnik (2025), Cai et al. (2024), de-la-Peña et al. (2024), Hassan et al. (2024), Ren et al. (2024), Olugbade et al. (2024), Omeh et al. (2025), Petridou and Lao (2024), Wu et al. (2025), Xie (2022).
Cluster 2 (Green)	Technology Acceptance and Digital Competence in Vocational Education	13	Edeh et al. (2021), Yang et al. (2023), Sánchez-Prieto et al. (2021), Vilppola et al. (2022), Kolosnichenko et al. (2021), Enochsson et al. (2021), Do et al. (2023).
Cluster 3 (Blue)	AI-Driven Innovation, Leadership, and Digital Transformation in Vocational Education	12	Alabbas and Alomar (2024), Aranda et al. (2023), Badawi and Drăgoicea (2023), Han et al. (2023), Sajja et al. (2025), Mohd Siraj et al. (2023).
Cluster 4 (Yellow)	Policy, Lifelong Learning, and Future Skills in the Industry 4.0 Era	12	Albizu and Estensoro (2024), Bolaños and Pilerot (2021), Kenayathulla (2021), Kim et al. (2024), Woods et al. (2022), Hearn et al. (2023).

Keyword Co-occurrence Analysis by Cluster

The keyword co-occurrence analysis yielded three major clusters, which capture the main research themes and conceptual relationships across the selected literature. As shown in Figure 4, the resulting network comprised 59 items, 1,673 links, and a total link strength of 17,140. In the visualisation, each colour represents a distinct thematic cluster, corresponding to a coherent strand of inquiry in the field. Table 4 outlines the three clusters together with their representative keywords and thematic directions.

Figure 4



Cluster 1 (Red), with 27 keywords, is centred on pedagogical innovation, practice-based learning, and technology-supported teaching in vocational education. The co-occurrence of “vocational education,” “technology,” “teaching,” “skill,” and “practice” indicates a focus on practical competency development through AI- and ICT-supported learning environments. The keyword pattern also connects employability, digital teaching competence, reflective practice, and instructional quality. This suggests that technology use is closely tied to both learner skill formation and teacher professional development (Do et al., 2023; Kolosnichenko et al., 2021; Sánchez-Prieto et al., 2021). This cluster reflects an experiential and practice-oriented strand of vocational education research.

Cluster 2 (Green) contains 16 keywords associated with AI applications, learning processes, model development, effectiveness, and implementation challenges. Terms such as “artificial intelligence,” “application,” “learning,” “model,” “effectiveness,” and “challenge” show that this cluster addresses the use of AI to support learning outcomes and adaptive teaching in vocational and technical education. The co-occurring terms suggest a research emphasis on feedback, personalisation, learner responsiveness, and the evaluation of AI-supported educational tools (De-la-Peña et al., 2024; Hassan et al., 2024; Ren et al., 2024). This cluster captures a learner-centred strand in which AI is linked to more responsive and individualised forms of vocational learning.

Cluster 3 (Blue), comprising 16 keywords, is shaped by the relationship between ICT use, vocational training, work contexts, and institutional conditions. The presence of terms such as “vocational training,” “ICT,” “impact,” “context,” and “work” suggests that this cluster is less focused on technology itself than on the environments in which digital tools are adopted and sustained. Its keyword structure connects school-based learning, workplace learning, leadership, teacher motivation, industry engagement, and knowledge exchange. This indicates that digital transformation in vocational education depends on contextual and organisational support (Albizu & Estensoro, 2024; Enochsson et al., 2021; Mohd Siraj et al., 2023). This cluster highlights a context-sensitive perspective on ICT integration in vocational education.

Table 4
Co-occurrence Analysis by Cluster

Cluster No. & Colour	Cluster Label	Number of Keywords	Representative Keywords
1 (Red)	Pedagogical Development and Skill-Oriented Practices in Vocational Education	27	"vocational education", "technology", "teaching", "teacher", "student", "skill", "development", "integration", "implementation", "industry", "practice", "quality", "experience"
2 (Green)	Artificial Intelligence Applications and Learning Effectiveness in CTE	16	"artificial intelligence", "application", "learning", "model", "effectiveness", "knowledge", "cte", "field", "challenge"
3 (Blue)	ICT Integration and Contextual Impact on Vocational Training	16	"vocational training", "ICT", "communication technology", "impact", "context", "factor", "level", "training", "work"

Burst Detection Analysis by Keywords

Burst-detection analysis identified 13 burst keywords between 2021 and 2025, reflecting shifts in research attention and the dynamic development of emerging topics over time. These burst terms indicate periods in which particular themes attracted intensified scholarly interest. Table 5 displays the keywords with the strongest bursts together with their burst strength, onset year, and duration.

Table 5
Keywords with Strongest Bursts (CiteSpace)

Keywords	Year	Strength	Begin	End	2021 - 2025
Technology Acceptance Model	2021	1.72	2021	2022	
ICT	2021	1.06	2021	2023	
Big Data	2021	1.03	2021	2021	
Work	2022	1.56	2022	2023	
Higher Education	2022	1.22	2022	2022	
Work-based Learning	2022	1.22	2022	2022	
Pedagogical Content Knowledge	2022	1.04	2022	2022	
Integration	2022	1.04	2022	2022	
Teacher Training	2022	1.04	2022	2022	
Digital Competence	2022	1.04	2022	2022	
Information	2023	2.21	2023	2023	
Performance	2023	2.02	2023	2023	
AI	2024	2.63	2024	2025	

The burst-detection results reveal a clear evolution in research attention from 2021 to 2025. In the earlier years, burst terms such as "Technology Acceptance Model" and "ICT" were associated mainly with digital adoption and instructional integration. This indicates that initial studies were largely concerned with the uptake of technology in vocational education. This emphasis later appeared to shift toward keywords such as "work-based learning" and "digital competence," marking a stronger focus on teacher development, curriculum innovation, and the pedagogical conditions required for effective technology use. In the most recent period, "AI"

emerged as the strongest and most sustained burst keyword, lasting from 2024 to 2025, while “performance” also indicated growing attention to learning and training outcomes. Although “generative AI” did not appear as an independent burst term, it may be partly captured under the broader “AI” keyword. These changes suggest that research attention has begun to extend beyond early concerns with adoption toward broader pedagogical, institutional, and practice-oriented questions in vocational education.

Discussion

The bibliometric results suggest an emerging change in research attention on digital technologies in vocational education. The bibliographic coupling and keyword co-occurrence analyses produced different but complementary cluster structures. Bibliographic coupling identified four intellectual groupings around learner empowerment, teacher digital competence, institutional innovation, and policy-oriented skill development. In contrast, keyword co-occurrence analysis identified three broader thematic areas related to pedagogical development, AI applications, and ICT integration. These differences reflect the distinct logics of citation-based and keyword-based mapping. Together, the two analyses show that the field is organised around both actor-level concerns and technology-oriented themes. Earlier studies in the dataset were mainly concerned with technological adoption and instructional integration, whereas more recent work appears to give greater attention to broader pedagogical, institutional, ethical, and policy-related concerns. Although previous reviews have discussed digitalisation trends and implementation challenges in vocational education (Hassan et al., 2021; Jiang et al., 2024), this study offers a more contextualised and multi-level account. Specifically, it links learner development, teacher competence, institutional transformation, and policy-oriented concerns within a single analytical framework.

Theoretical Implications

The bibliometric findings suggest an emerging movement from adoption-oriented perspectives toward a broader socio-technical understanding of digital transformation in vocational education. Early technology adoption models such as the TAM (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003) provided an important basis for explaining initial uptake. However, digital technologies are no longer understood merely as tools to be accepted or rejected. Rather, they are increasingly approached as integral components of educational ecosystems in which technological affordances interact with human agency, organisational culture, and institutional conditions (Edeh et al., 2021; Han et al., 2023). This bibliometric pattern may extend technology acceptance perspectives by showing that digital transformation in vocational education could be understood as an ongoing socio-technical process shaped by learner agency, teacher readiness, institutional support, and policy conditions.

Another notable development mapped in the bibliometric results is the move away from a narrow concern with performance improvement toward broader affective, ethical, and sustainability-related dimensions. The increasing prominence of learner empowerment, AI literacy, ethical awareness, and sustainability, together with greater attention to adaptive, learner-responsive, and practice-oriented pedagogies, reflects a broader reconceptualisation of digital technologies in vocational education (Avsec & Rupnik, 2025; Hassan et al., 2024). In this view, digital technologies, particularly AI, are increasingly understood not simply as tools for improving performance, but as resources that can also support emotional engagement and responsible educational practice. This may extend the theoretical scope of educational technology research by linking affective learning, digital ethics, sustainability education, and

vocational identity development more explicitly with vocational pedagogy (Kryger & Qvortrup, 2025). It also situates the findings within UNESCO's Sustainable Development Goal 4, which emphasises inclusive, equitable, and high-quality education through responsible innovation (UNESCO, 2021).

Additionally, teachers, institutions, and policy contexts are better seen not as separate background variables, but as interconnected dimensions of digital transformation. Teachers' professional preparation, institutional support, and cross-sector collaboration appear to shape the direction and sustainability of technology integration (Hearn et al., 2023; Vilppola et al., 2022). Theoretically, this finding suggests that digital transformation in vocational education can be conceptualised as a multi-level process shaped by learners, teachers, institutions, and policy environments, rather than as a classroom-level issue alone.

Practical Implications

From a practical perspective, the identified bibliometric themes suggest that digital technologies should be embedded in authentic, experiential, and practice-oriented teaching environments. Vocational education research increasingly links digital tools with active learning, workplace relevance, and learner responsiveness, rather than simply with the digitisation of traditional instruction (Kolosnichenko et al., 2021; Sajja et al., 2025). This pattern points to the need for aligning curriculum design with industry expectations while ensuring that digital tools enhance rather than replace human judgement, creativity, and problem-solving.

Teachers play a central role in sustaining digital transformation. Effective technology integration appears to depend not only on infrastructure, but also on teachers' preparedness, AI literacy, ethical awareness, and opportunities for continuous professional learning (Omeh et al., 2025; Petridou & Lao, 2024; Wu et al., 2025). Professional development could therefore include structured AI literacy training, ethical use of learner data, and practical guidance on designing human–technology collaborative activities, interpreting algorithm-generated feedback, and fostering students' critical digital awareness. Peer mentoring and institutional support structures may also help teachers participate actively in shaping innovation rather than functioning merely as policy implementers.

At the institutional level, leadership, governance, and organisational culture are essential to digital transformation. In vocational education, successful implementation depends on leadership support, governance structures, and the institutional conditions that shape implementation (Mende et al., 2025; Mohd Siraj et al., 2023). Institutions should therefore treat digital technologies not only as classroom tools, but also as part of a broader organisational infrastructure that requires coordinated leadership, transparent governance, and meaningful cooperation with industry partners. Mechanisms such as digital transformation task forces or AI ethics committees may be particularly useful for balancing innovation with inclusion, accountability, and social responsibility.

At the policy level, digital transformation could be linked more closely with lifelong learning and future workforce development. In this context, digital technologies are increasingly connected to wider debates about employability, resilience, and responsible governance (Hearn et al., 2023; Kim et al., 2024; Woods et al., 2022). Policy frameworks could prioritise two actions: establishing clear guidelines for ethical AI use in vocational education and funding continuous AI and ICT professional development for vocational teachers. These measures may help ensure that digital transformation remains inclusive, future-oriented, and socially sustainable.

Limitations and Future Research Directions

Although this study provides an evidence-based overview of research on digital technologies in vocational education, several limitations should be noted. First, the analysis relied only on the WoS Core Collection. Although this choice helped maintain data consistency, it may have narrowed international coverage by excluding studies from Scopus, ERIC, Google Scholar, regional databases, and non-English or practice-oriented vocational education outlets. As a result, relevant studies indexed in Scopus, ERIC, or regional databases may not have been included. Future research could therefore expand the dataset by incorporating non-English and locally published studies. Second, the time frame (2021–2025) captures only the early stage of post-pandemic digital transformation. More longitudinal research is needed to determine whether the patterns identified here remain stable or continue to change as emerging digital technologies, including generative AI, develop further. Third, bibliometric mapping helps reveal the broad structure of the field, but it offers limited insight into how digital transformation unfolds in pedagogical, organisational, and policy contexts. Future studies could combine bibliometric methods with qualitative approaches, such as interviews, case studies, and classroom or institutional observations, to gain a fuller understanding of how digital technologies are experienced and implemented across different vocational settings.

Conclusions and Implications

In conclusion, this study shows that research on digital technologies in vocational education has moved beyond issues of access and adoption toward a socio-technical understanding of digital transformation. The bibliographic coupling and keyword co-occurrence results reveal four interconnected levels of development: learner empowerment and AI literacy, teacher readiness and professional learning, institutional innovation and governance, and policy alignment with lifelong learning and workforce development. This provides a clearer account of how the field is structured and how its priorities are changing. The main contribution of this study is to show that digital transformation in vocational education is not developing as a purely technical agenda, but as a multi-level educational process shaped by pedagogy, human agency, institutional capacity, and governance. On this basis, future research should prioritise the relationship between AI literacy, teacher professional development, and institutional readiness. At the policy level, clearer guidelines for ethical AI use and sustained investment in AI and ICT professional development for vocational teachers are needed.

Declarations

The authors declare no conflict of interest. Ethical approval and research guidance were obtained under INTI International University's doctoral supervision framework.

Acknowledgements

The authors express sincere gratitude to INTI International University, Malaysia, for its academic guidance and research support. The authors also acknowledge the developers of CiteSpace (v6.3.R1) and VOSviewer (v1.6.20) for their contributions to bibliometric visualization.

Author Notes

The authors used AI-assisted tools (ChatGPT and Grammarly) solely for language

refinement and formatting. The content, interpretation, and conclusions remain the authors' own responsibility, consistent with the journal's AI disclosure policy and UNESCO's SDG 4 principles on responsible AI use in education.

References

- Ahmad, S. R., Isa, N., Liaw, A., Nazari, M. L., Abdullah, N. P., Rani, M. H., Ahmad, A., Abd Rahman, A. Q., & Mohd Lokman, A. (2023). Enhancing employability and empowerment: Unveiling factors within PERDA-TECH for sustainable development. *Journal of Technical Education and Training*, 15(3), 235–250. <https://doi.org/10.30880/jtet.2023.15.03.021>
- Alabbas, A., & Alomar, K. (2024). Tayseer: A novel AI-powered Arabic chatbot framework for technical and vocational student helpdesk services and enhancing student interactions. *Applied Sciences*, 14(6), 2547. <https://doi.org/10.3390/app14062547>
- Albizu, M., & Estensoro, M. (2024). The role of vocational training in ICT firms: The revelation. *Journal of Vocational Education & Training*, 76(2), 234–252. <https://doi.org/10.1080/13639080.2024.2304298>
- Aranda, J. R., Campos, I., Cosculluela, C., San Martin, J., & De Pablos, C. (2023). Continuous vocational training in response to the challenge of Industry 4.0: Required skills and business results. *Journal of Industrial Engineering and Management*, 16(2), 256–274. <https://doi.org/10.3926/jiem.4665>
- Ayanwale, M. A., Omeh, C. B., Oyeniran, F. M., & Kanu, C. C. (2025). Ethical compliance and institutional policy support for artificial intelligence integration in African TVET education: A structural equation modeling approach. *PLOS ONE*, 20(12), Article e0335747. <https://doi.org/10.1371/journal.pone.0335747>
- Avsec, S., & Rupnik, D. (2025). From transformative agency to AI literacy: Profiling Slovenian technical high school students through the five big ideas lens. *Systems*, 13(7), 562. <https://doi.org/10.3390/systems13070562>
- Badawi, S., & Drăgoicea, M. (2023). Towards a value co-creation process in collaborative environments for TVET education. *Sustainability*, 15(3), 1792. <https://doi.org/10.3390/su15031792>
- Bolaños, F., & Pilerot, O. (2021). Digital abilities, between instrumentalization and empowerment: A discourse analysis of Chilean secondary technical and vocational public policy documents. *Journal of Education and Work*, 34(7–8), 768–787. <https://doi.org/10.1080/13636820.2021.1973542>
- Bo, Z., Pek, L. S., Cong, W., Tiannan, L., Krishnasamy, H. N., Ne'matullah, K. F., & Arar, H. (2025). Transforming translation education: A bibliometric analysis of artificial intelligence's role in fostering sustainable development. *International Journal of Learning, Teaching and Educational Research*, 24(3), 166–190. <https://doi.org/10.26803/ijlter.24.3.9>
- Cai, M., Luo, H., Meng, X., & Liu, J. (2024). Exploring the multidimensional impact of ICT on academic achievement and mental health: Evidence from a large-scale survey of higher vocational students in China. *Journal of Computer Assisted Learning*, 40(4), 1898–1921. <https://doi.org/10.1111/jcal.12995>
- Cui, Y., & Li, M. (2025). Factors affecting vocational education teachers' adoption of Gen AI: A multi-group analysis by discipline and region. *Interactive Learning Environments*, 1–17. <https://doi.org/10.1080/10494820.2025.2583194>
- Dahalan, F., Alias, N., & Shaharom, M. S. N. (2023). Gamification and game-based learning for vocational education and training: A systematic literature review. *Education and Information Technologies*, 29, 1279–1317. <https://doi.org/10.1007/s10639-022-11548-w>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- de-la-Peña, C., Roda-Segarra, J., & Chaves-Yuste, B. (2024). Improving English foreign language (EFL) performance using artificial intelligence in vocational education and training (VET). *Journal of Technical Education and Training*, 16(1), 006. <https://doi.org/10.30880/jtet.2024.16.01.006>
- Do, H. T. H., Nguyen, N. D., Pham, T. N., Mai, A. N., & Le, H. T. T. (2023). Impact of vocational education and training on decent job opportunities regarding information and communication technology. *Journal of Technical Education and Training*, 15(1), 73–84. <https://doi.org/10.30880/jtet.2023.15.01.007>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>

- Edeh, N. I., Ugwoke, E. O., Abanyam, F. E., Madu, M. A., Augustine, N.-O., & Pulife, M. C. (2021). Extending technology acceptance model in learning-management-systems in TVET institutions: The impact of vocational educators' gender, experience and perception. *Journal of Technical Education and Training*, 13(3), 009. <https://doi.org/10.30880/jtet.2021.13.03.009>
- Enochsson, A.-B., Kilbrink, N., Andersén, A., & Ådefors, A. (2021). Obstacles to progress: Swedish vocational teachers using digital technology to connect school and workplaces. *International Journal of Training Research*, 19(2), 111–127. <https://doi.org/10.1080/14480220.2021.1979623>
- Han, X., Yang, C., & Zhou, Q. (2023). Digital transformation in vocational education: Present situation, problems, and countermeasures. *Frontiers of Education in China*, 18(1), 70–82. <https://doi.org/10.3868/s110-008-023-0005-2>
- Hassan, R. H., Hassan, M. T., Naseer, S., Khan, Z., & Jeon, M. (2021). ICT enabled TVET education: A systematic literature review. *IEEE Access*, 9, 84739–84758. <https://doi.org/10.1109/ACCESS.2021.3085910>
- Hassan, R. H., Hassan, M. T., Sameem, M. S. I., & Rafique, M. A. (2024). Personality-aware course recommender system using deep learning for technical and vocational education and training. *Information*, 15(12), 803. <https://doi.org/10.3390/info15120803>
- Hearn, G., Williams, P., Rodrigues, J. H. P., & Laundon, M. (2023). Education and training for Industry 4.0: A case study of a manufacturing ecosystem. *Education + Training*, 65(8–9), 1070–1084. <https://doi.org/10.1108/ET-10-2022-0407>
- Jiang, X., Xu, J., & Xu, X. (2024). An overview of domestic and international applications of digital technology in teaching in vocational education: Systematic literature mapping. *Education and Information Technologies*, 29, 16867–16899. <https://doi.org/10.1007/s10639-024-12528-y>
- Kenayathulla, H. B. (2021). Are Malaysian TVET graduates ready for the future? *Higher Education Quarterly*, 75(3), 453–467. <https://doi.org/10.1111/hequ.12310>
- Kim, J. Y. J., Kim, E., & Lim, D. H. (2024). A meta-analysis of the effects of lifelong vocational education in South Korea. *European Journal of Training and Development*, 48(7–8), 749–765. <https://doi.org/10.1108/EJTD-02-2023-0026>
- Kolosnichenko, M. V., Yezhova, O. V., Pashkevich, K. L., Kolosnichenko, O. V., & Ostapenko, N. V. (2021). The use of modern digital technologies in the design and technology VET in Ukraine. *Journal of Technical Education and Training*, 13(4), 005. <https://doi.org/10.30880/jtet.2021.13.04.005>
- Kryger, M., & Qvortrup, A. (2025). Conceptualizing and developing vocational identity: A scoping review of research in vocational education and training. *Vocations and Learning*, 18, 15. <https://doi.org/10.1007/s12186-025-09371-8>
- Mende, C., Oswald-Egg, M. E., & Caves, K. (2025). Vocational education and training (VET) system governance: A systematic literature review. *Journal of Vocational Education & Training*, 77(5), 1419–1453. <https://doi.org/10.1080/13636820.2025.2461586>
- Mohd Siraj, M. A. M., Md. Rami, A. A., Omar, R., Abdul Aziz, N. A., & Mohd Anuar, M. A. (2023). The relationship between principals' leaderships towards TVET teachers' motivation in implementing ICT. *Journal of Technical Education and Training*, 15(3), 008. <https://doi.org/10.30880/jtet.2023.15.03.008>
- Morál-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. *El Profesional de la Información*, 29(1), e290103. <https://doi.org/10.3145/epi.2020.ene.03>
- OECD. (2023). *Is education losing the race with technology? AI's progress in maths and reading* (Educational Research and Innovation series). OECD Publishing. <https://doi.org/10.1787/73105f99-en>
- Olugbade, D., Edwards, B. I., & Ojo, O. A. (2024). Facilitating cognitive load management and improved learning outcomes and attitudes in middle school technology and vocational education through AI chatbot. *Journal of Technical Education and Training*, 16(3), 009. <https://doi.org/10.30880/jtet.2024.16.03.009>
- Omeh, C. B., Odelewe, C. J., & Hu, X. (2025). Application of artificial intelligence (AI) technology in TVET education: Ethical issues and policy implementation. *Education and Information Technologies*, 30, 5989–6018. <https://doi.org/10.1007/s10639-024-13018-x>

- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Öztürk, O., Kocaman, R., & Kanbach, D. K. (2024). How to design bibliometric research: An overview and a framework proposal. *Review of Managerial Science*, 18(11), 3333–3361. <https://doi.org/10.1007/s11846-024-00738-0>
- Petridou, E., & Lao, L. (2024). Identifying challenges and best practices for implementing AI additional qualifications in vocational and continuing education: A mixed methods analysis. *Studies in Continuing Education*, 46(3), 385–400. <https://doi.org/10.1080/02601370.2024.2351076>
- Ren, J., Edwards, B. I., & Jamiat, N. (2024). Impact of AI software on improving learning outcomes and attitudes of music students in Chinese vocational schools. *Journal of Technical Education and Training*, 16(3), 010. <https://doi.org/10.30880/jtet.2024.16.03.010>
- Rusa, R. C., Salisu, M. A., Hussain, M. A. M., Kamal, M. F. M., Hanapi, Z., Idris, M. O., Bamiro, N. B., & Kayode, B. K. (2023). Systematic review of Malaysia technical and vocational education (TVET) sustainability framework to increase the marketability of graduates using PRISMA. *Jurnal Kejuruteraan*, 51(2), 51–63. [https://doi.org/10.17576/jkukm-2023-si6\(2\)-06](https://doi.org/10.17576/jkukm-2023-si6(2)-06)
- Sajja, R., Pursnani, V., Sermet, Y., & Demir, I. (2025). AI-assisted educational framework for floodplain manager certification: Enhancing vocational education and training through personalized learning. *IEEE Access*, 13, 42401–42413. <https://doi.org/10.1109/ACCESS.2025.3548591>
- Sánchez-Prieto, J., Trujillo-Torres, J. M., Gómez-García, M., & Gómez-García, G. (2021). Incident factors in the sustainable development of digital teaching competence in dual vocational education and training teachers. *European Journal of Investigation in Health, Psychology and Education*, 11(3), 758–769. <https://doi.org/10.3390/ejihpe11030054>
- UNESCO. (2021). *AI and education: Guidance for policy-makers*. United Nations Educational, Scientific and Cultural Organization. <https://doi.org/10.54675/PCSP7350>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478. <https://doi.org/10.2307/30036540>
- Vilppola, J., Lämsä, J., Vähäsantanen, K., & Hämäläinen, R. (2022). Teacher trainees' experiences of the components of ICT competencies and key factors in ICT competence development in work-based vocational teacher training in Finland. *International Journal for Research in Vocational Education and Training*, 9(2), 131–157. <https://doi.org/10.13152/IJRJET.9.2.1>
- Woods, R., Doherty, O., & Stephens, S. (2022). Technology-driven change in the retail sector: Implications for higher education. *Industry and Higher Education*, 36(2), 115–124. <https://doi.org/10.1177/09504222211009180>
- Wu, H., Li, D., & Mo, X. (2025). Understanding GAI risk awareness among higher vocational education students: An AI literacy perspective. *Education and Information Technologies*, 30, 14273–14304. <https://doi.org/10.1007/s10639-024-13312-8>
- Xie, H. (2022). Recommendation of English reading in vocational colleges using linear regression training model. *Computational Intelligence and Neuroscience*, 2022, 6786111. <https://doi.org/10.1155/2022/6786111>
- Yang, C., Guo, R., & Cui, Y. (2023). What affects vocational teachers' acceptance and use of ICT in teaching? A large-scale survey of higher vocational college teachers in China. *Behavioral Sciences*, 13(1), 77. <https://doi.org/10.3390/bs13010077>
- Zawacki-Richter, O. (2021). The current state and impact of Covid-19 on digital higher education in Germany. *Human Behavior and Emerging Technologies*, 3(1), 218–226. <https://doi.org/10.1002/hbe2.238>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, 16, Article 39. <https://doi.org/10.1186/s41239-019-0171-0>
- Zhou, B., Lim, S. P., Kabir, N., Bouteraa, M., & Asna, A. (2026a). Artificial intelligence in mobile-interactive EFL learning environments: A bibliometric analysis. *International Journal of Interactive Mobile Technologies (iJIM)*, 20(8), 33–49. <https://doi.org/10.3991/ijim.v20i08.59677>

Zhou, B., Lim, S. P., Kabir, N., Asna, & Lu, T. N. (2026b). From automation to socio-affective learning: A bibliometric analysis of artificial intelligence in English as a foreign language education. *Problems of Education in the 21st Century*, 84(1), 229–247. <https://doi.org/10.33225/pec/26.84.229>

Received: April 20, 2026

Revised: May 09, 2026

Accepted: June 18, 2026

Cite as: Zhou, B., Lim, S. P., Kabir, N., Tao, J., Yang, J., & Wang, C. (2026). Digital technologies in vocational education: From technology adoption to socio-technical transformation. *Problems of Education in the 21st Century*, 84(3), 525–541. <https://doi.org/10.33225/pec/26.84.525>

Bo Zhou	Faculty of Education and Liberal Arts, INTI International University, Nilai, Negeri Sembilan 71800, Malaysia. E-mail: i24028791@student.newinti.edu.my ORCID: https://orcid.org/0009-0003-4218-8654
Seong Pek Lim (Corresponding author)	Faculty of Education and Liberal Arts, INTI International University, Nilai, Negeri Sembilan 71800, Malaysia. E-mail: seongpek.lim@newinti.edu.my ORCID: https://orcid.org/0000-0002-0322-7572
Nahdia Kabir	Faculty of Business and Communications, INTI International University, Nilai, Negeri Sembilan 71800, Malaysia. E-mail: i24028316@student.newinti.edu.my ORCID: https://orcid.org/0009-0005-6254-0621
Jin Tao	Business School, Yangzhou Polytechnic Institute, Yangzhou, China. E-mail: i24028010@student.newinti.edu.my ORCID: https://orcid.org/0009-0004-5735-3218
Jiaying Yang	South China Normal University, Guangzhou, Guangdong Province, 510631, China. E-mail: yjylsz@foxmail.com ORCID: https://orcid.org/0009-0008-8816-0418
Cong Wang	Faculty of Education and Liberal Arts, INTI International University, Nilai, Negeri Sembilan 71800, Malaysia. E-mail: i24026767@student.newinti.edu.my ORCID: https://orcid.org/0009-0000-8294-8716



PROBLEMS
OF EDUCATION
IN THE 21st
CENTURY

GUIDE FOR AUTHORS

ISSN 1822-7864 /print/ ISSN 2538-7111 /Online/

General Information

The publication language is English. All authors must take care of the language revision on their own. The language must be clear and accurate. The work should be written in an impersonal style. The editor reserves the right to send the manuscript to be reviewed. If English is a second language for the author, please consider having the manuscript proof read and edited before submitting.

Format of Manuscripts

Title

The main research idea/problem should be reflected in the title. The title should show the nature of the research/study. It is recommended to avoid the title of the question form. The recommended length for a title is no more than 12 words (APA, 2.01, p. 23).

The title of the paper 14-point, bold with capital letters, align left; titles in the text (chapters) 12-point bold, not numbered; sub-titles (subchapters) 12-point, italic, not numbered. There must be 1 empty line before and after a title or a subtitle. The text chapters must be separated by 1 empty row. The title should be concise and informative. Avoid abbreviations.

Author names and affiliations

Full names/surnames should be provided. Please indicate affiliations of the author(s). All the e-mails should be indicated below.

Abstract

The first page of the manuscript must begin with the title of the paper and an abstract which should be about 150 - 250 words. For the papers reporting original research, state in brief: the primary/main aim (the research questions addressed or any hypothesis tested); the research design; the methods and procedures employed; the number of participants; the main outcomes and results; the conclusions drawn from these data and results, including their implications for further research or application/practice. An abstract represents briefly a content of a text. Do not cite references in the abstract. The abstract should grip the reader's attention.

Keywords

Please provide 3 to 5 keywords in alphabetical order. Note that a keyword does not have to be made of only one word. At least one of these should indicate the topic area and one should indicate the methodology of the research.

The structure of the manuscript (recommended)

The body of the text of the manuscript must generally have the following parts:

- abstract + keywords;
- introduction (it can be divided into some subchapters if needed);
- methodology of research (it is recommended to divide /rubricate);
- results of research;
- discussion;
- conclusions and/or implications;
- acknowledgements (if any);
- references (in APA style, 7th Ed);
- appendix (if any).

P.S. The structure can be different if the paper is only theoretical qualitative research.

The length of the manuscript

The manuscript should be not shorter than 6 pages (including references, tables and figures). Manuscripts should be typed on A4, in Times New Roman 12-point font size, single-spaced, 2.5 cm with all the margins, word-document (Word 6.0 or later) format.

Acronyms

Acronyms should be defined the first time they appear.

Tables and figures

Tables and figures should be valuable, relevant, and visually attractive. Tables (made in Word or another software) and figures must be referred to in the text and numbered in the order of their appearance. Each table and figure should have a complete, descriptive title; and each table column an appropriate heading. The texts in tables and figures should be 11-point (in some cases 10) and their width should be 12 cm at maximum. The figures should be in format .jpg (unless done in Word or Excel); resolution 1200 dpi. Figures, tables (black and white colour, without ground-colour) and captions should be inserted within the manuscript at their appropriate locations. All the graphics (figures) must be editable. The font size should be Times New Roman for all figures and tables. Figures should be carefully explained in the text and cited in numerical order. It is the author's responsibility to obtain permission to reproduce illustrations, tables, etc. from other publications.

Discussion

Focus the discussion to the two important questions: What is already known about your topic? What your research adds? It is recommended that the aim and major findings of the research should be reminded. And then the similarities and differences of the findings with previous research studies should be exemplified in detail.

Conclusions

This part is not a summary. Bring out the significance of your research. Show how you've brought closure to the research problem, and point out remaining gaps in knowledge by suggesting issues for further research. The main research outcome should be clearly seen.

References

The title „References“ must be used. APA style for writing references in the text and in the reference list must be used. References in the text should be presented in parentheses (Knox, 1988; Martin, 1995). If necessary, the page can be indicated: (Martin, 1995, p. 48). The list of references should be presented after the text.

The author should make sure that there is a strict one-to-one correspondence between the names and years in the text and those on the list. All the references should be listed in alphabetical order by author's name.

For the sake of accuracy, references should always be as updated as possible, also in the interest of the readers and researchers on the topic the paper is dealing with.

Notes

Note 1: Manuscripts in which references are not in the APA style will be returned without review.

Note 2: References to online sources should include the type of medium (such as “serial online” or “monograph online”), the date of that specific reference (if applicable), the uniform resource locator (URL), and the date that the source was accessed. A source accessed online should always be referenced accordingly, even if it is also published in printed form.

Note 3: All papers must meet the criteria of originality and scientific quality. Obviously, they must also comply with style and format requirements. The paper will not be subject to further review, if the manuscript is NOT WITHIN THE SCOPE and/or there is POOR USAGE OF LANGUAGE (all manuscripts must be written in clear and grammatical English).

Note 4: Submitted papers will be assessed based on their novelty, technical quality, potential impact, and clarity of writing.

Note 5: All papers are checked by CrossCheck system.

Editorial Board

Updated: July 2018

Website: <http://www.scientiasocialis.it/pec/>

**Problems of Education in the 21st Century,
ISSN 1822-7864 (Print) ISSN 2538-7111 (Online)**

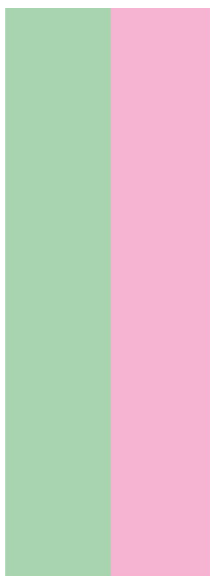
Vol. 84, No. 3, 2026

<i>Compiler</i>	Vincentas Lamanuskas
<i>Designer</i>	Jurgina Jankauskienė
<i>Paste-up artist</i>	Loreta Šimutytė-Balčiūnienė
<i>English language proofreader</i>	Ilona Ratkevičienė

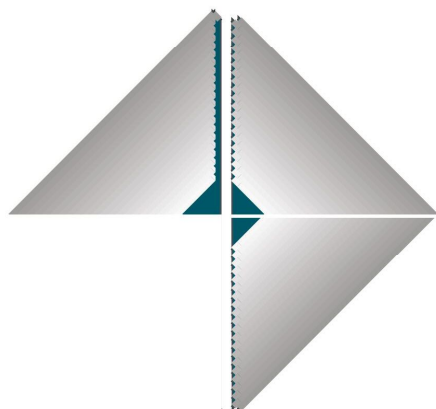
25 June 2026. Publishing in Quires 10.625. Edition 80.

<i>Publisher</i>	Scientia Socialis Ltd. in cooperation with SMC „Scientia Educologica“ Donelaicio Street 29, Siauliai, Lithuania E-mail: scientia@scientiasocialis.lt Phone: +370 687 95668
------------------	---

<i>Printing</i>	„Šiaulių spaustuvė“ Ltd. 9A P. Lukšio Street LT-76207 Šiauliai, Lithuania Phone: +370 41 500 333. Fax: +370 41 500 336 E-mail: info@dailu.lt
-----------------	--



...'Therefore, today it is worth talking not about whether environmental education is necessary at the preschool stage. It is much more important to ask whether we are giving it enough attention, quality conditions, and real non-declarative educational content. If we want the person of the future to be responsible for the environment, we must start from the very beginning - from kindergarten, from a daily example, from small but consistent actions that become the basis for a child's perception of the world. This leads to the need for deeper and more detailed research on this issue. Such research in the field of environmental education in preschool should primarily be directed at assessing the long-term effectiveness of experiential and inquiry-based learning, in order to determine which specific practical activities are most likely to form sustainable habits and promote value internalization. Also critically important are studies that analyze the mechanisms of family-kindergarten interaction/cooperation and educational interventions that reduce contradictions between declared values and everyday behaviour, since children learn primarily by imitating adults. In addition, systematic studies of future preschool teacher training programmes are needed, revealing gaps in competencies and modeling ways to integrate environmental education into professional training not episodically, but consistently and systematically'...



Lamanauskas, V. (2026). Environmental education in preschool age as an educational priority. *Problems of Education in the 21st Century*, 84(2), 254–258. <https://doi.org/10.33225/pec/26.84.254>



ISSN 1822-7864 (Print), ISSN 2538-7111 (Online)

